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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OPERATORS MANUAL:

ELECTRONIC COUNTER-COUNTERMEASURES:

RADAR COURSE DIRECTING CENTRAL

(NIKE-AJAX, NIKE-HERCULES, AND IMPROVED

NIKE-HERCULES AIR DEFENSE GUIDED MISSILE SYSTEMS

AND NIKE-HERCULES ANTI-TACTICAL BALLISTIC

MISSILE SYSTEM (ATBM)) (U)

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TECHNICAL MANUAL

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HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., 9 January 1961**ELECTRONIC COUNTER-COUNTERMEASURES:
RADAR COURSE DIRECTING CENTRAL (U)**

	Paragraph	Page
CHAPTER 1. INTRODUCTION		
Section I. General		
Purpose and scope.....	1	3
Definition of terms.....	2	3
Electronic countermeasures	3	5
Electronic counter-countermeasures	4	5
II. Electronic countermeasure techniques		
Intercept capabilities	5	6
Reflection ECM techniques	6	7
Transmission ECM techniques	7	9
Tactics	8	11
III. Electronic counter-countermeasures techniques		
Against reflection ECM techniques	9	12
Against transmission ECM techniques	10	12
CHAPTER 2. SYSTEM OPERATION		
Section I. Acquisition radars (NIKE-AJAX and NIKE-HERCULES systems)		
General	11	13
ECM environment	12	13
ECM analysis and reporting	13	13
ECCM devices and capabilities	14	14
ECCM devices and capabilities for NIKE-HERCULES systems with Anti-Jam Display (AJD).....	14.1	20
General operating principles	15	20.6
I.1. Acquisition radars (Improved NIKE-HERCULES radar systems)		
General	15.1	20.9
ECCM devices and capabilities	15.2	20.9
General operating principles	15.3	20.18
I.2. Acquisition radars (NIKE-HERCULES anti-tactical ballistic missile systems)		
General	15.4	20.18.1
LOPAR/HIPAR ECCM devices and capabilities of the ATBM system	15.5	20.18.1
LOPAR ECCM devices and capabilities of the ATBM system	15.6	20.18.1
EFS/ATBM HIPAR ECCM devices and capabilities of the ATBM system	15.7	20.18.3
General operating principles of the NIKE-HERCULES ATBM system	15.8	20.18.6
II. Tracking radars (NIKE-AJAX and NIKE-HERCULES systems)		
General	16	20.19
ECM environment	17	21
ECM analysis and reporting	18	21
ECCM devices and capabilities	19	21
General operating principles	20	24
II.1. Tracking radars (Improved NIKE-HERCULES radar systems)		
General	20.1	24
ECCM devices and capabilities	20.2	24
General operating principles	20.3	24.4

CONFIDENTIAL

	Paragraph	Page
CHAPTER 3. COMBATTING ENEMY ELECTRONIC COUNTERMEASURES		
Section I. Acquisition radars (NIKE-AJAX and NIKE-HERCULES systems)		
Deception techniques	21	25
Confusion techniques	22	27
Obscuration techniques	23	29
Obscuration techniques (NIKE-HERCULES systems with AJD)	23.1	33
I.1. Acquisition radars (Improved NIKE-HERCULES radar systems)		
Deception techniques	23.2	34
Confusion techniques	23.3	34.1
Obscuration techniques	23.4	34.2
I.2. Acquisition radars (NIKE-HERCULES anti-tactical ballistic missile systems)		
Obscuration techniques (LOPAR of ATBM system)	23.5	34.4
EFS/ATBM HIPAR deception techniques	23.6	34.5
EFS/ATBM HIPAR confusion techniques	23.7	34.5
EFS/ATBM HIPAR obscuration techniques	23.8	34.6
II. Target tracking radar (NIKE-AJAX and NIKE-HERCULES systems)		
Deception techniques	24	4
Confusion techniques	25	35
Obscuration techniques	26	37
II.1. Tracking radars (Improved NIKE-HERCULES radar systems)		
Deception techniques	26.1	44.1
Confusion techniques	26.2	44.2
Obscuration techniques	26.3	44.3
CHAPTER 4. OPERATION IN PRESENCE OF UNINTENTIONAL INTERFERENCE SIGNALS		
Sources of unintentional interference	27	45
Detection and identification	28	45
Operation in presence of friendly interference	29	45

CHAPTER 1

INTRODUCTION

Section 1. GENERAL

1. (U) Purpose and Scope

a. The introduction of each new weapon has always been followed by a new development to offset its advantages. Just as radar was devised as a defense against enemy aircraft, electronic countermeasures (ECM) were devised to counter the effectiveness of radar. Thus, the next essential area of development involved a means of offsetting the effects of ECM, that is, electronic counter-countermeasures (ECCM). This manual is concerned with ECM and ECCM in connection with the radars of the NIKE missile systems. The adverse effects of ECM can be overcome, or at least minimized, if you, the radar operator, (1) have a thorough understanding of the nature of ECM, (2) can recognize and identify the effects of ECM, and (3) are able to apply effectively the ECCM techniques at your disposal. The purposes of the information presented in this manual are to acquaint you, as a NIKE system radar operator, with the various types of interference which may be encountered during operation in an ECM environment, and to provide guidance for radar operation in such an environment. It is assumed that you are thoroughly familiar with NIKE systems operation in a non-ECM environment.

b. A mission conducted under ideal conditions and with no radar interference, either from the enemy or from friendly sources, is a complex operation in itself. Any ECM action by the target, or other enemy aircraft, or any unintentional interference from friendly sources, increases the complexity of the operation. Since ECM has become a standard technique in military operations and may be expected in an enemy encounter, it is essential to consider radar operation in an ECM environment. It is necessary that you be prepared to cope with all types of interference to which your radars are vulnerable. Although unintentional friendly interference cannot be called ECM, it does present

problems similar to enemy interference and is included when we speak of ECM environment. In this first chapter, we will consider ECM and ECCM techniques as an introduction to the problems involved in coping with an ECM environment. In the remaining chapters, we will study in more detail the ECM threat to the NIKE systems, show how to recognize the various forms of ECM, and discuss optimum means at hand for combatting each type. Emphasis is placed on problems created by enemy countermeasures since the most common types of friendly interference will have similar effects while presenting fewer problems.

2. (U) Definition of Terms

The following list provides definitions of common electronic countermeasures terminology. In addition to terms used in this manual, there are included other commonly used terms which are related to the information contained herein. Because of the conflicts of electronic countermeasures terms, the definitions presented herein apply only to this manual and should not be considered a general electronic countermeasures glossary.

a. *Active ECM.* Electronic countermeasures, including reflection and transmission techniques, which degrade the performance of the radars.

b. *Angels.* Name given to the relatively large reflection ECM devices such as rope and corner reflectors.

c. *Barrage Jamming.* Jamming which exists across a wide band of frequencies, such as S-band or X-band. The extent of frequency coverage constituting barrage jamming is a matter of interpretation. Barrage jamming is generally intended for use against any number of radars which may be operating in the affected frequency band, as opposed to spot jamming,

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which is intended for use against one particular radar.

d. Blinking. A transmission ECM technique whereby the enemy retransmits the radar signal alternately from two antennas mounted on opposite extremities of an aircraft to create angle tracking errors in the target tracking radar.

e. Chaff. Small strips of reflecting material cut to a length corresponding to the target-radar frequency, and released from the aircraft in packages, which in turn open in the air stream to allow the chaff to disperse.

f. Chaff Corridor. Chaff released steadily and in large quantities to form a large chaff cloud (corridor) through, or behind, which enemy aircraft may fly undetected.

g. Confusion ECM. Active ECM techniques whereby the enemy presents false information to the radars with the intention of distracting the operator or creating uncertainty as to which is a real target among many false targets.

h. Corner Reflector. A three-dimensional reflecting device designed to reflect most of the intercepted radar energy back to the radar, regardless of the corner reflector's orientation in space.

i. Deception ECM. Active ECM techniques whereby the enemy presents false information to the radars in such a manner that this information is not recognizable as being false.

j. Decoy. A small, unmanned, expendable aircraft designed to present to the radar a return echo comparable in size and characteristics to that of a much larger, bomber type aircraft.

k. Electronic Countermeasures (ECM). Action taken by the enemy against the radars to (1) gain technical and tactical data, (2) restrict operation, or (3) reduce effectiveness. This term includes both active and passive ECM techniques.

l. Electronic Counter-Countermeasures (ECCM). Action taken to reduce the effectiveness of ECM.

m. Gate Snatching. A term synonymous with range gate stealing (*v* below).

n. Goof Balls. Another name for corner reflectors.

o. Hole. A flaw in the frequency spectrum

of a jamming signal where the jamming signal strength decreases.

p. Jamming. A term synonymous with active ECM, although not usually applied to deception ECM.

q. Lock-On Jamming. Jamming technique whereby the jammer locks on to the radar transmitter frequency and follows any frequency change made by the radar operator.

r. Obscuration ECM. Active ECM techniques whereby the enemy either conceals targets, as with chaff corridor, or overpowers target echoes, as with some types of transmission ECM.

s. Passive ECM. Electronic countermeasure techniques whereby the enemy intercepts and analyzes transmissions from the radars in order to plan more efficient and more effective active ECM.

t. Rabbits. Spiral strobes appearing on the PPI as a result of non-synchronized pulse modulated jamming.

u. Railing. Sharp spikes, similar to the transmitted pulse, appearing on the tracking indicators as a result of pulse modulated jamming.

v. Range Gate Stealing. A technique whereby a jamming signal gains control of the range tracking circuits, thus creating a range error in the target tracking radar.

w. Reflection ECM. ECM which is generated by reflecting the radar signal back toward the radar with the intention of furnishing false information to the radar. Also includes the use of radar energy absorbing material and the reflection of the radar signal in directions other than toward the radar, with the intention of making a target partially invisible to the radar.

x. Rope. Reflection ECM device consisting of a long strip of reflective material which, when released from the aircraft, unwinds from a weighted spool and falls slowly in an almost vertical position, suspended from a paper parachute.

y. Secondary Screening. The tactic whereby an enemy aircraft employs ECM primarily for the protection of other aircraft.

z. Self Screening. The tactic whereby an enemy aircraft employs ECM primarily for its own protection.

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aa. Serrodyne Modulation. A deception technique whereby the enemy retransmits the radar signal after shifting the frequency slightly. This technique is intended to introduce angle tracking errors into a monopulse radar, such as the target tracking radar.

ab. Spoofing. Technique whereby the enemy utilizes the radar transmitted pulse to trigger the transmission of several pulses which closely resemble the target echo on the radar indicators. These spoofer targets may be offset from the target position in range and/or azimuth.

ac. Spot Chaff. Chaff released, one package at a time, to cause relatively small, isolated returns, similar to aircraft returns, as opposed to the large obscuring returns from a chaff corridor.

ad. Spot Jamming. Jamming which is concentrated within a relatively narrow band of frequencies. As opposed to barrage jamming, which may affect several radars operating within a wide frequency band, spot jamming is usually directed against the operating frequency of a particular radar.

ae. Swept Frequency Jamming. A technique which combines the power concentration of spot jamming with the frequency coverage of barrage jamming, whereby a jamming signal is tuned back and forth over a selected band of frequencies. The jamming signal is thereby tuned through the radar receiver bandpass creating strong impulse signals.

af. Transmission ECM. ECM which is generated by transmitting electromagnetic energy toward the radar with the intention of furnishing false information to the radar.

3. (U) Electronic Countermeasures

The two most common classifications of ECM are passive and active. Passive ECM is the term applied to the interception of radar signals by the enemy, for the purpose of analyzing these signals and planning active countermeasure accordingly. The ability of the enemy to intercept the radiations of the NIKE systems is discussed in paragraph 5. However, this manual is primarily concerned with active ECM which actually affect the performance of the radars. Active ECM consist of reflection techniques and transmission techniques. Reflection tech-

niques imply the use of various devices which reflect the radar energy back to its source to produce false target returns or to obscure target returns. Included in reflection techniques is the use of material which absorbs part of the radar energy to make a target partially invisible to the radars. Transmission techniques imply the transmission, by the enemy, of electromagnetic energy which is received by the radar along with the target echo. Active ECM techniques are discussed in section II and are treated in greater detail in TM 11-750. Active ECM techniques, both reflection and transmission, may be designed to (1) deceive by providing false information to the radar in such a way that you do not realize that an electronic countermeasure environment exists, (2) confuse by causing multiple target returns to appear on the indicators so that it is difficult to determine which is the real aircraft target, or (3) obscure by overpowering the target return to the extent that it is no longer detectable on the indicators.

4. (U) Electronic Counter-Countermeasures

The problems involved in countering the countermeasures may appear insurmountable. Further analysis will show that this is not necessarily true. In many aspects the heavy ground radar has definite natural advantages, especially when operating against airborne jammers. The defending radars have the advantage of large, high power radars; whereas the airborne jammer is limited in size and power capability and, at the same time, must be highly versatile to be effective. To illustrate the power advantage of the ground radar, let us examine the case of a jammer at the target designed to obscure the target return on the acquisition radar plan position indicator. At long ranges the jammer has little trouble overpowering the radar echo; however, as the target approaches, the power of the radar echo increases faster than the power of the jamming signal as seen at the receiver. Depending on the relative power of the radar and the jammer, there may be a range at which the radar echo is detectable on the indicator. Whether or not this is a usable range will depend on the actual powers of the radar and the jammer. Modern radar de-

sign techniques, and special anti-jam features aid the ECCM cause considerably, but you, the operator, are the most important ECCM "device." Your radar may be equipped with the

latest electronic anti-jam features, but the effectiveness of many of these features will be limited by your knowledge of when and how to use them.

Section II (CMHA). ELECTRONIC COUNTERMEASURE TECHNIQUES

5 (CMHA). Intercept Capabilities

a. Before employing active ECM, enemy aircraft will attempt to intercept and analyze the radiations from ground radars being used against them. By the use of intercept receivers and various analyzing equipment, the enemy is able to determine certain facts concerning the technical characteristics and tactical uses of the radars.

b. The enemy may use the intercepted radar data in two ways. The intercept receiver may display the various detected data to an operator. The operator may then initiate active ECM action based on these data. For example, if this operator learns the frequency of a radar operating against him, he may dispense a certain size chaff (par. 6a) or tune a jamming transmitter to the proper frequency. The other method is the inclusion of the intercept receiver in an automatic intercept-jamming system, thus partially eliminating the need for operator control. For example, the intercept receiver may detect the frequency of a radar and automatically cause the jamming transmitter to be tuned to that frequency and turned on. The repeating techniques described in paragraph 7g are other examples of the automatic intercept-jam operation.

c. It is possible for airborne intercept receivers to detect all the radiated signals from a NIKE battery. These radiations are of varying use to the enemy, depending on the particular radar and the range from the battery to the intercept receiver. The radars of the NIKE systems, if pointed in the direction of the intercept aircraft, provide detectable signals to an intercept receiver long before the intercept aircraft is within the detection range of these radars. The enemy is thus made aware of a threat to him before he is seen on the radar indicators. At a corresponding range, the missile tracking

radar provides relatively weak signals which are easily masked by other radars in the area because the missile track radar antenna will not point at the target prior to missile intercept.

d. In a given area there will generally be a number of NIKE systems, along with other radar stations, resulting in a large number of radiation sources within the line-of-sight of the intercept receiver at long ranges. Although the enemy is able to detect the radiations, his ability to distinguish between sources and analyze any one signal is limited at this long range. As the intercept receiver approaches to within the detection and tracking ranges of the radars, the task of distinguishing between and analyzing the radiations is made easier. As range decreases, the target containing the intercept receiver may be able to determine which radars pose the most imminent threat to him, analyze the corresponding radiations, and take countermeasure action accordingly.

e. At this shorter range, the signal from the acquisition radar is readily detectable as the main lobe passes through the azimuth of the target containing the intercept receiver. The intercept operator may determine which tracking radar, out of many, is actually tracking his aircraft. This is possible because the received signal strength from this radar will be greater than from radars that are tracking other aircraft. However, since it is possible that more than one target tracking radar will be tracking a given target, the target requires a highly directional antenna to distinguish between the separate sources of radiation.

f. Listed in (1) through (8) below are some of the technical characteristics of a radar which an intercept system may be able to determine.

- (1) *Frequency.* Radar frequency can be determined by accurately calibrated

receiving equipment. This is the most important information to the enemy.

- (2) *Pulse repetition frequency.* The pulse repetition frequency of received radar transmissions can be determined by comparison (on an oscilloscope) with calibrated oscillator signals, and by other techniques.
- (3) *Pulse width.* Radar pulse width of the received radar pulse can be determined by observing the pulse on a spectrum analyzer or on an oscilloscope with a calibrated time base.
- (4) *Receiver band pass.* Radar receiver band pass can be approximated by analysis of the radar pulse width.
- (5) *Probable maximum range.* Radar maximum range can be approximated from the pulse repetition frequency data.
- (6) *Beam width.* The beam width of the acquisition radar can be estimated by the use of directional receiving antennas in conjunction with calibrated signal strength indicators. This information can be obtained only if the acquisition radar antenna is scanning through the target azimuth at a regular rate.
- (7) *Probable accuracy.* Radar accuracy can be estimated from pulse width and beam width data.
- (8) *Type of radar.* The type of radar can be determined through evaluation of the above data. For example, a coded transmission would indicate missile tracking radar.

6. (U) Reflection ECM Techniques

Reflection ECM techniques include the oldest forms of electronic countermeasures. You can expect them to be used in any enemy encounter because of their relative simplicity compared to some of the more sophisticated transmission techniques. New ways have been devised to use some of the older reflecting devices, such as chaff; and new devices have come into being, such as dummy aircraft decoys and radar energy-absorbing materials. The most common devices which may be effective against the

radars of the NIKE systems are listed and described below and are illustrated in figure 1.

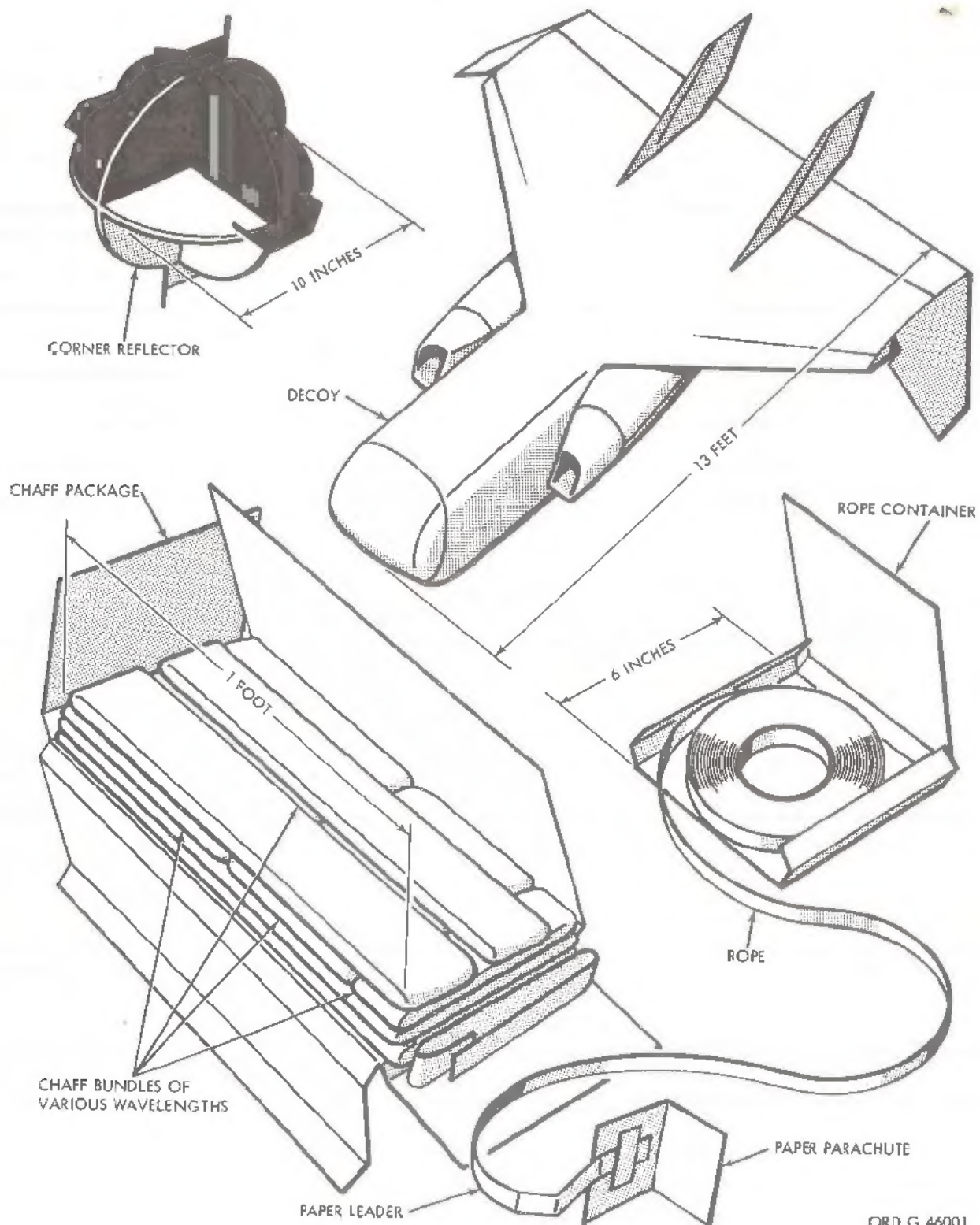
a. *Chaff.* Chaff consists of thin strips of light-weight reflecting material such as tin foil, aluminum foil, or metallic-coated paper. The strips are cut to a length corresponding to one-half wavelength of the energy transmitted by the radar against which the chaff is to be used. The length of the individual strips in a package of chaff will generally be varied sufficiently to allow the chaff to be effective against the entire frequency range of a radar. The chaff, dispensed from the aircraft in small packages which open to allow the chaff to disperse, disperses rapidly, falls slowly, and drifts with the wind at the rate of approximately two-thirds of the wind speed. Chaff may be dispersed from the aircraft in several ways. It may be dropped so that it begins to disperse immediately, or the opening of the packages may be delayed so that the chaff does not begin to disperse until it has fallen well away from the aircraft. It may also be launched out from the aircraft in any direction. Chaff may be dispersed one package at a time, to simulate an aircraft target, or it may be dispensed in large quantities to form a chaff cloud or corridor through, or behind, which an attacking force may fly undetected.

b. *Rope.* Rope consists of either a single long ribbon of reflecting material or a number of small reflectors cut to a size equal to one-half wavelength of the radar energy and spaced on some form of paper backing to form the long ribbon. Rope is wound on a weighted spool with one end attached to a small parachute by means of a cloth leader. When the rope is dropped, it unwinds from the spool and falls slowly in a nearly vertical position, supported by the parachute. Rope will normally be effective only against the acquisition radar, to which it will present an indication similar to that of an aircraft. This reflecting device, along with the other larger reflecting devices described below, are sometimes referred to as angels.

c. *Corner Reflectors.* Corner reflectors are made up of a number of plane surfaces of rigid reflecting material such as metal mesh or sheet metal. These reflecting surfaces are assembled to form a three-dimensional multi-faced reflector which reflects a portion of any intercepted

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Figure 1. Reflection ECM devices.

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radiation directly back to its source, regardless of the orientation of the reflector. When designed efficiently, a corner reflector will reflect approximately the same amount of energy as a large aircraft. Corner reflectors may be effective against both the acquisition and tracking radars. Against the acquisition radar, these devices will usually be dropped with parachutes, in the same manner as rope, to simulate aircraft targets.

d. Decoys. The word decoy has many connotations, but in this manual we will assign and restrict the word to a relatively newly developed ECM device. This device is a small dummy aircraft which is bluntly shaped and usually equipped with corner reflectors in order to present a radar cross-section comparable to a much larger aircraft. The decoy aircraft, when launched from attacking aircraft, are difficult to distinguish from real aircraft unless the act of launching is detected on the radar indicators. This is more true of decoys than of the other devices discussed above, because the decoys have flight characteristics very similar to real aircraft. In addition, decoys may be equipped with some type of ECM transmitter to further complicate the environment.

e. Absorbing Material. The use of radar energy absorbing material on aircraft is another relatively new technique. The objective is to reduce the radar cross-section of the aircraft and thus decrease the effective range of a radar. This material may be resonant and thus effective against only a narrow band of frequencies, or it may be nonresonant, and effective against a relatively wide band of frequencies.

7. (U) Transmission ECM Techniques

The common transmission ECM techniques which may be effective against the radars of the NIKE systems are described in *a* through *h* below.

a. Unmodulated CW. Unmodulated continuous wave (cw) jamming consists of an unmodulated rf signal transmitted by the enemy at a single frequency and constant amplitude. A completely unmodulated cw jamming signal has the advantage of power concentration at the one frequency. However, the lack of frequency coverage is a disadvantage to the enemy.

Therefore, this technique is effective against the NIKE systems only if the jammer is able to jam within the radar receiver bandpass and is able to follow quickly and accurately any change of frequency which you may make.

b. Amplitude Modulated CW. Amplitude modulated cw jamming consists of an rf carrier (cw) signal. The amplitude is varied by the modulating signal. This modulating signal may be one or a combination of different waveshapes. The most common are sine wave, pulse, square wave, and noise. If the modulating signal consists of a sine wave, square wave, or pulse at only one frequency, amplitude, and phase, the jamming pattern on the indicator will be relatively simple. When many modulating signals, each with different characteristics, are used, the jamming pattern becomes more complex. Pulse modulation will have a different effect depending on whether the pulses are synchronized or nonsynchronized with the radar pulse repetition frequency. Synchronized pulses occur at a frequency which is an exact multiple of the radar pulse repetition frequency. Noise is generally considered the most effective type of modulation at the present time. A noise modulating signal consists of sharp, narrow peaks at random frequency, amplitude, and phase. Depending upon the quality of the noise, this type of modulation can be effective across a relatively wide frequency band. It is as effective at one frequency as another within the frequency band of the noise.

c. Frequency Modulated CW. A frequency modulated signal consists of an r-f carrier (cw) which is shifted in frequency by a modulating signal. The modulating signal will cause the carrier frequency to sweep above and below the unmodulated, or center, frequency. The range of frequencies that the carrier is swept through increases as the amplitude of the modulating signal increases. The rate at which the carrier is swept to either side of center is dependent upon the frequency of the modulating signal. The carrier can be swept back and forth by either mechanical or electronic means. The mechanical method involves changing the physical size of the oscillator cavity in the transmitter. The electronic method is accomplished by applying various waveforms to the transmitter

as modulating signals. The most common waveforms in use are sine, sawtooth, triangular, and noise.

d. Modulation Combinations. Just as a cw jamming signal becomes more effective when some type of modulation is employed, jamming is more effective when more than one type of modulation is employed at the same time. Perhaps the most effective combination of modulating techniques is the use of noise to modulate the amplitude, along with a sawtooth waveshape to modulate the frequency. The noise amplitude modulation provides a jamming signal of a certain bandwidth centered about the cw carrier signal. The frequency modulation then sweeps the amplitude modulated signal across a certain band of frequencies.

e. Swept Frequency. Swept frequency jamming is a type of frequency modulation. The term "swept frequency" is used to identify the type of frequency modulation that produces intermittent jamming signals on the radar indicators. This intermittent appearance is caused by the jamming transmitter sweeping through a band of frequencies that is large compared to the bandpass of the receiver. On a PPI, the jamming will appear as broken strobe lines. On the tracking indicators, the jamming will appear as "bursts" of jamming signals.

f. Direct Noise. As mentioned previously, amplitude modulation of a cw signal with noise is probably the most effective single modulation technique. It should be emphasized here that noise jamming can generally be considered the one factor of electronic countermeasures which will cause you the most trouble. However, the use of noise as a modulating signal is not the most effective use of noise available. As you will see in chapter 3, a cw jamming signal poses a much less serious threat to your radars than noise. Modulating a cw signal with noise makes it very difficult to eliminate the cw carrier from the signal. The presence of this cw element detracts from the effectiveness of the jamming. It would therefore seem that the desired result is to produce noise without a cw content. A technique that will produce this signal is called direct noise amplification. In one method of generation, the inherent noise of a traveling wave tube is amplified by a series of traveling wave tubes

to the desired power level, then transmitted. This type of noise jamming can be designed to cover an entire frequency band such as S-band, or X-band and is one of the most difficult jamming environments for you to operate in.

g. Repeating Type Techniques. You will note that all the transmission ECM techniques described thus far have one common characteristic; that is, the jammer originates the jamming signal without making direct use of the radar transmitted pulse. One exception would be pulse-modulated cw jamming when it is synchronized with the radar pulse repetition frequency. This technique is brought out only to introduce a more sophisticated type of jammer which makes direct use of the radar transmitted pulse by first receiving the pulse, operating on it in some way, then retransmitting it back to the radar. This type of jammer is more complex, but is much more efficient in its use of power. The ways in which the jammer may operate on the radar pulse to supply false information to the radar include the following.

- (1) The jammer may receive the pulse, amplify, and retransmit it first with minimum time delay. By slowly increasing the amplitude of the retransmitted pulse to a level greater than that of the target echo, the enemy may "capture" automatic gain control. This high amplitude pulse tends to decrease your receiver gain enough to make the lower amplitude target echo very small or invisible. Then the enemy gradually increases the time delay in the retransmission of subsequent radar pulses. In this manner, the range gate can be gradually drawn away, or "stolen", from the reduced amplitude true target echo. If the enemy has reduced your receiver gain sufficiently, you will not detect this stealing of the range gate. At this point the jammer has two choices. He may continue to retransmit the radar pulse at a certain time delay and thereby introduce a range tracking error into the radar. He may suddenly cease operation after drawing the range gate away from the

target echo and cause an interruption in range tracking.

- (2) The jammer may slightly change the frequency or shift the phase of the radar pulse to affect the angle tracking performance of the target tracking radar.
- (3) Another technique, which is effective against both the acquisition and target tracking radars, is the transmission by the jammer of several pulses each time the radar pulse is received. If these pulses can be made to closely resemble the target echo, they will appear on the radar indicators as additional aircraft targets. This technique is called spoofing. The spoofer targets may be offset from the aircraft position in range and/or azimuth for the acquisition radar and range only for the target track radar.
- (4) The jamming aircraft may employ an antenna at each wingtip through which the radar pulses are retransmitted first from one antenna and then from the other. This technique is called blinking. If you are using automatic angle tracking, this technique will cause the target tracking radar antenna to hunt between the transmitting antennas on the aircraft. If the enemy is able to switch antennas at a certain optimum rate, he may be able to cause the target tracking radar to oscillate between the two antennas to the extent that it will slew completely off target.

h. Tuning Methods. Techniques similar to swept frequency described in *e* above consist of tuning the jamming transmitter in order to maintain transmission at the frequency of the radar being jammed. Elaborate tuning techniques are almost a necessity if jamming is to be effective against modern radars. Tuning methods may be used to enhance the effectiveness of all forms of transmission ECM except direct noise. Like the methods of sweeping the frequency back and forth, tuning may be accomplished electronically or mechanically. How-

ever, the important consideration governing the effectiveness of tuning methods is whether the tuning is accomplished manually or automatically. Manual tuning will usually involve some mechanical or electronic process controlled by an operator. Automatic tuning will involve either a mechanical or an electronic process controlled through a closed loop intercept-jamming system. The most dangerous to you is automatic electronic tuning. Such a technique may allow the jammer to track your most radical frequency changes with no discernable delay. One intercept-jam technique operates much like frequency sweeping. An intercept receiver determines the radar frequency and controls the application of a sawtooth waveshape to the jamming transmitter to tune the transmitter to the correct frequency. Another such technique, usually called a comb filter, employs several transmitting elements controlled by the intercept receiver. Each of the several transmitting elements is set up to transmit a jamming signal, such as noise amplitude modulated cw, covering a certain portion of a wide band of frequencies. When the intercept receiver senses the radar frequency, it automatically turns on that transmitting element which may be effective against the radar.

8. (U) Tactics

The techniques described above represent the most common "tools" the enemy may use to create an ECM environment. These tools can be used in many ways and in various combinations. The enemy's tactical ECM philosophy is difficult to predict. Your best defense against ECM is a thorough knowledge and operational proficiency of the ECCM capabilities of your system. An ECM environment will be the normal environment in an enemy encounter. There are two general classifications of ECM tactics, self screening and secondary screening. Self screening is the action taken by an aircraft to protect itself against detection. Secondary screening is the action taken by aircraft devoted primarily to ECM for the protection of other aircraft. Let us examine a few tactics to illustrate.

- a.* A single target aircraft may forward launch bundles of chaff to form a protective

cover into, or behind which it will fly. While concealed by the chaff, the aircraft can change course and at the same time launch decoys or drop corner reflectors to prevent you from identifying the real aircraft on your indicators as all these "targets" emerge from the chaff cover.

b. You may detect an attacking formation of aircraft with the acquisition radar and at the same time one or more undetected ECM aircraft may approach at low altitude. Just as you are preparing to fire at the first aircraft, the low-flying aircraft "pop up" and begin jamming from a relatively short range. The element of surprise may be the deciding factor in aborting

your mission. Never be complacent. Always be prepared for a surprise.

c. Two aircraft may approach on slightly different azimuths. One may transmit jamming signals while the other does not. Then they may switch their roles. In addition, while one is transmitting, the other may maneuver and then transmit on a different azimuth. In this manner, they may leave you uncertain as to how many aircraft are approaching. Also, their purpose may be to distract your attention away from a more lethal aircraft approaching on still another azimuth. Never concentrate your attention at one point to the extent that you fail to notice other targets.

Section III. ELECTRONIC COUNTER-COUNTERMEASURES TECHNIQUES

9. (U) Against Reflection ECM Techniques

The ECCM techniques which you use in a given ECM environment will be more effective if you are able to recognize the nature of the environment. For example, the devices used in creating a reflection ECM environment have two important characteristics which affect your choice of ECCM action. These two characteristics are (1) a motion much different from that of the aircraft, and (2) an effectiveness against a wide range of frequencies. The former characteristic may not apply to decoy aircraft. However, the general idea is, if you can determine that some type of reflection ECM is being used, you should realize that changing radar frequency will normally be ineffective. Possibly, because of the motion factor, use of the moving target indicator (MTI) will be your most effective action. The details of ECCM action are contained in the following chapters. Always keep in mind that there is a best way which may save valuable seconds in seeing through an ECM environment.

10. (U) Against Transmission ECM Techniques

The characteristics of reflection ECM do not apply to transmission ECM. Consider the situation in which several target indications appear on the plan position indicator in a straight line. It may be difficult to determine whether the indications are caused by a series of chaff drops or by the spoofing technique. However, chaff will quickly slow down and begin to disperse; whereas spoofer targets may maintain a motion similar to that of the aircraft. Many transmission ECM techniques can be counteracted by a change in radar frequency. Frequency changing is probably the one technique which is effective against most transmission ECM techniques, but it is not always the best action to take first in each case. In the case of the target tracking radar, at one time it may be better to interrupt transmission while changing frequency, as against a jammer designed to track your frequency change. At another time it may be better not to interrupt transmission while changing frequency, as when looking for a hole in wide band noise jamming.

CHAPTER 2 (CMHA)

SYSTEM OPERATION

Section I (CMHA). ACQUISITION RADARS (NIKE-AJAX AND NIKE-HERCULES SYSTEMS)

11 (CMHA). General

As the acquisition radar operator, you will be one of the first in your battery to learn that an enemy operation is in progress. The task of acquiring, tracking, and destroying an enemy target begins with you. You will be working against time in obtaining target information and providing this information to the target tracking radar. You must assume that the enemy will employ ECM to prevent you from accomplishing your mission. Therefore, the quicker you are able to supply information to the target tracking radar to "get it in the game," the better will you, as a team, be able to accomplish your mission in an ECM environment.

12 (CMHA). ECM Environment

All electronic countermeasures, whether reflection or transmission, will be designed to do one or more of three things: deceive, confuse, or obscure.

a. Deception. Deception techniques which you can expect to be used against the acquisition radar include decoys, spot chaff (single packages of chaff), single units of rope, single corner reflectors, and spoofing. The deceptive quality of spot chaff, rope, and corner reflectors does not last long. Soon after these devices are released from the aircraft and begin to slow down, they can be recognized and then become a confusing factor. Spoofing is considered deceptive only if a small number of spoofer targets are generated.

b. Confusion. Confusion techniques you can expect to be used against the acquisition radar include volumes of chaff, rope, corner reflectors, spoofing, and some forms of modulated cw. When spoofer targets begin to appear in large masses on your indicator, you will begin to realize that all are not real aircraft. However, you may become confused as to which ones are real and which are spoofer targets.

c. Obscuration. Obscuration techniques you can expect to be used against the acquisition radar include chaff corridor (large amounts of chaff), unmodulated cw, modulated cw, and direct noise.

13 (CMHA). ECM Analysis and Reporting

When you are aware that electronic countermeasures are being used against you, immediately determine the type of ECM, the direction of the jammer, the number of jammers, and the effectiveness and intensity of the jamming. This information is to be reported to your superior as quickly and as accurately as possible without delaying your ECCM action. The specific procedures to be used in reporting ECM will be set forth in the applicable standard operating procedure for your command. The information below will serve as a guide for reporting the various characteristics.

a. Type of ECM. Detailed information which will aid you in identifying the type of ECM is presented in chapter 3 of this manual.

b. Direction and Number of Jamming Sources. The direction and number of jamming sources can be closely approximated in most cases by observation of the PPI. If the jamming is powerful enough to penetrate your antenna side lobes and appear over a wide azimuth area of the PPI, there will be high-intensity strobes at the azimuth of the jamming sources.

c. Effectiveness of ECM. The effectiveness of ECM is reported on the basis of four defined conditions. Using these four conditions, you can report the situation with a minimum of words. This method of reporting effectiveness does not apply to deception techniques. The four conditions are illustrated throughout the manual and are defined as follows:

- (1) *Condition 0.* ECM not observed.
- (2) *Condition 1.* ECM experienced. No degradation of operation.
- (3) *Condition 2.* ECM degrades operation but ECCM permits effective continued operation.
- (4) *Condition 3.* ECM prevents effective continuation of operation despite use of ECCM.

Figure 2. (Deleted).

Figure 3. (Deleted).

Figure 4. (Deleted).

Figure 5. (Deleted).

Figure 6. (Deleted).

14 (CMHA). ECCM Devices and Capabilities

There are some controls and features of the acquisition radar which have a particular significance in ECCM operation. Not all of these controls and features were designed specifically as ECCM devices, but all have use against some form of ECM. Always observe the initial setting of a control before using it so that the control can be readily returned to its normal position.

a. *Plan Position Indicator (PPI) and Precision Indicator (PI).* The focus, intensity, and video gain controls for the PPI and PI should be adjusted according to normal adjustment procedures for optimum presentation on the indicators. Once these adjustments are made, they should *not* be touched when operating against ECM. Any gain adjustment used against ECM should be an adjustment of receiver gain, not indicator video gain. Special instructions concerning indicator observation in the presence of certain types of ECM are presented in chapter 3.

b. *RECEIVER GAIN Control.* The RECEIVER GAIN control has two applications as an ECCM device against transmission ECM. One application is to reduce receiver gain until only a narrow jamming strobe remains on the indicator. This strobe provides you with jam-

mer azimuth information which you can designate to the target tracking radar. The second application of this control is to reduce receiver gain to prevent the receiver from being saturated. Remember that, as seen by the receiver, the power of the target echo increases faster than the power of the jamming signal as range decreases. However, if the jamming signal is strong enough to saturate the receiver, the target echo will never be detectable even if it is stronger than the jamming. Thus, by reducing receiver gain to prevent receiver saturation, you will have a better chance of seeing the target. Figure 7 shows the effects of reducing gain to obtain the main jamming strobe. Note that, as gain is reduced, all returns on the indicator are reduced in intensity along with the jamming. In figure 7, view A, the highest intensity jamming seems to be at approximately 3725 mils. The single strobe obtained in figure 7, view B, by a reduction in receiver gain enables you to designate this azimuth more accurately. When designating targets, using the strobe line, set the acquisition range unit to mid range if the target video cannot be seen on the strobe.

c. *Moving Target Indicator (MTI).* The MTI function is to cancel out echos from fixed targets while passing echos from moving targets. Properly adjusted MTI will be effective in reducing return signals from most reflection ECM devices because these devices will appear very similar to fixed targets to the MTI. Effectiveness of MTI will vary with wind velocity. If wind velocity is high, the MTI cancellation will not be complete, but may help the situation.

d. *INCREASE FREQ - DECREASE FREQ Switch.* This switch may be used to vary the frequency of the tunable magnetron to evade the jamming frequency or to look for holes in the spectrum of wide band jamming.

e. *Aided Range Operation.* This feature is helpful in a situation where a target flies through chaff cover. If the use of MTI does not effectively cancel chaff returns, set up an aided



Figure 7 (CMHA). Effects of reducing receiver gain to obtain main jamming strobe. (U)

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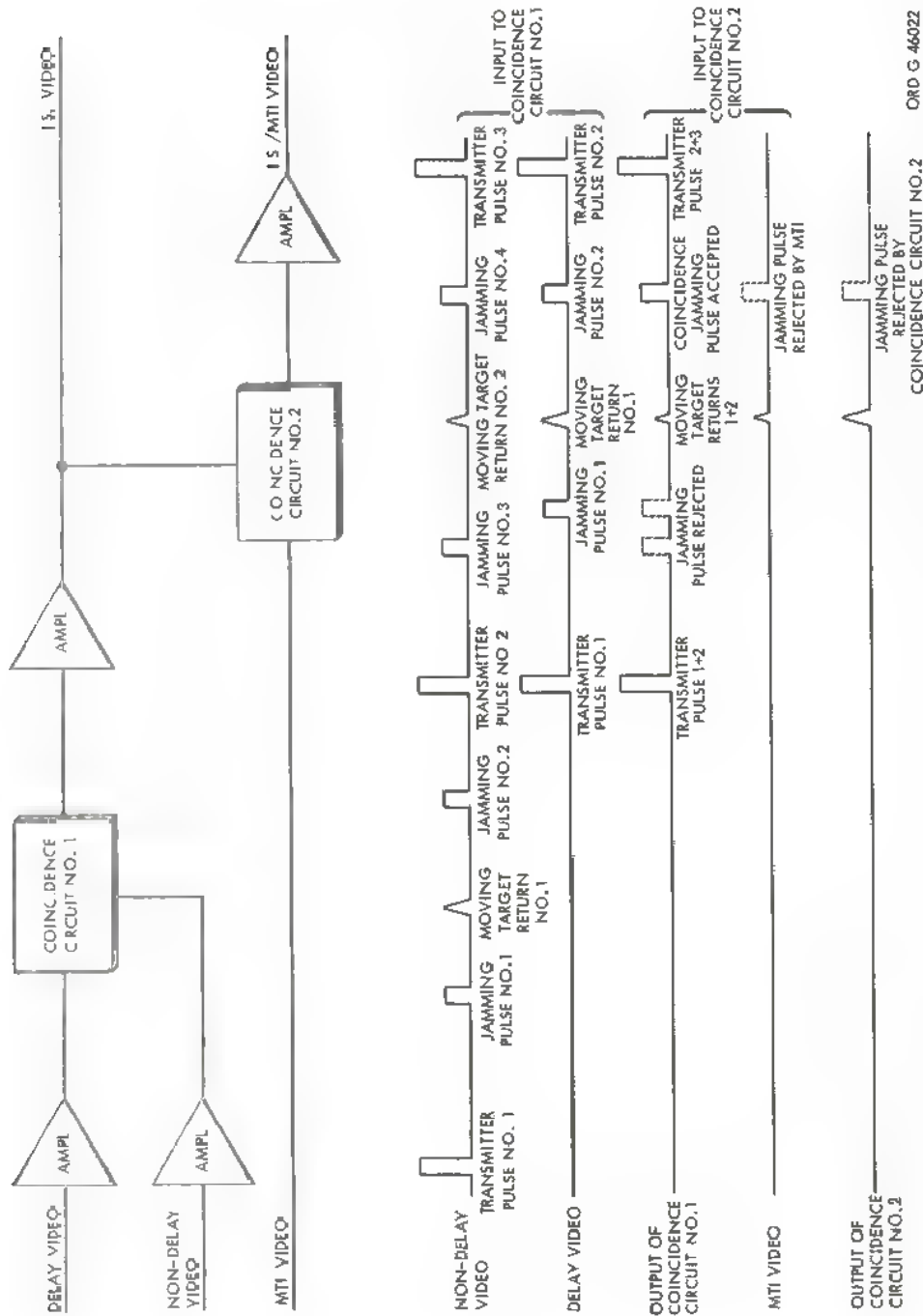
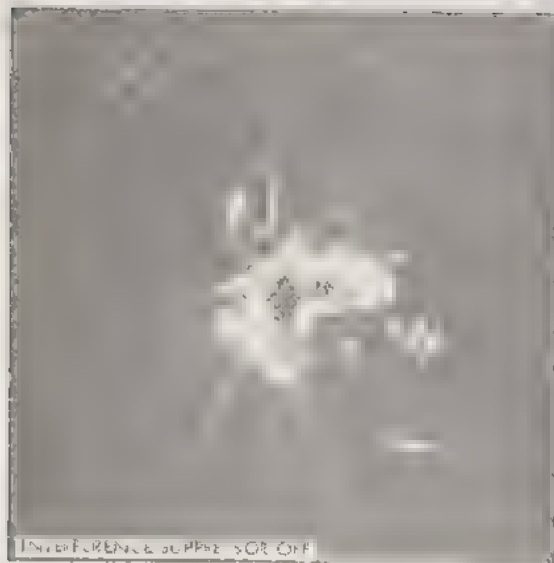


Figure 8. Interference suppressor operation, simplified block diagram.

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Figure 9. Effects of interference suppressor circuits on noise modulated jamming.



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Figure 10. Effects of interference suppressor circuits on high intensity frequency modulated jamming

range rate to assist in tracking the target through the chaff. Care must be taken not to rely completely on the aided rate, because the target may make radical changes in course or speed and dispense some reflection devices while concealed by the chaff. (This feature does not exist in NIKE-AJAX.)

f. Interference Suppressor (IS) Switch.

- (1) The IS switch energizes circuits which reduce the effects of jamming signals which possess a random characteristic. Another, and more descriptive, name for interference suppression is coincidence detection. The circuits compare the returns caused by successive transmitted pulses. Each time a given return is not present for two successive transmissions, that return is cancelled. Since an aircraft will return an echo



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Figure 11. (CMHA). Effects of expanded sweep on random pulse modulated jamming.

from each transmitted pulse, true target information will not be affected.

- (2) Figure 8 shows operation of interference suppressor action. Applied through two amplifiers to a coincidence detection circuit are two video signals. One signal is applied without delay. The other is applied after having been delayed for a length of time equal to the time between two successive transmitter pulses. In this manner, all return signals caused by transmitter pulse one are compared with all return signals caused by transmitter pulse two. The coincidence circuit will pass only signals which appear the same distance from the transmitter pulse in both cases. Since jamming pulse one in the delayed video and jamming pulse three in the non-delayed video are not coincident, they are rejected by coincidence circuit one. Jamming pulse two and jamming pulse four are allowed to pass because they are coincident. Moving target returns one and two are also passed unaffected by coincidence circuit one. Even though this return is moving, it is impossible for an aircraft to move fast enough between two transmitter pulses to make the return non-coincident.
- (3) The output of coincidence circuit one is amplified and made available for application to the indicator through relays controlled by the IS switch. This output of coincidence circuit one is also applied to coincidence circuit two along with MTI video. Although jamming pulses two and four were passed by coincidence circuit one, they are cancelled by coincidence circuit

two. This circuit operates differently. It cancels signals which are coincident and equal in amplitude. Although the moving target returns are coincident, they are not cancelled because they are slightly different in amplitude due to target flaring. The output of coincidence circuit two is amplified and made available for application to the indicator by the MTI controls and IS switch.

- (4) Figure 9 shows the effects of the interference suppressor circuits on noise modulated jamming. Figure 10 shows the effects of the interference suppressor circuits on high intensity frequency modulated jamming. When this photograph was taken, the radar was being subjected to condition three jamming and the IS switch was on during half the scan.

g. Expanded Sweep. The EXPANSION and EXPANDED POSITION controls may be used to expand the sweep in the area of the target on the PPI. The expanded sweep can be very helpful in operation against ECM by providing a better defined presentation of the target area. However, you must remember that by using an expanded sweep you blind yourself to a large portion of the normal presentation. Therefore, you should use expanded sweep only to concentrate on a target which has been definitely selected for engagement. Figure 11 shows the effects of using expanded sweep against random pulse modulated jamming. Note that four targets are visible on the expanded sweep while only two are visible on the normal sweep.

h. Radar Select Capability of NIKE-HERCULES Systems With an Auxiliary Acquisition Radar (AAR). NIKE-HERCULES Systems with an AAR provide you with a choice of two acquisition radar systems which contain many ECCM features capable of combatting severe ECM tactics. With this combination, you have an over-all system capability of operating in two frequency bands. This provides you with the capability of selecting the radar system that is least affected by transmission ECM techniques. This selection can be accomplished by setting the RADAR SELECTED switch to the AAR or NAR (NIKE acquisition radar) po-

sition. In the AAR position, you select the auxiliary acquisition radar presentation and in the NAR position, you select the NIKE acquisition radar presentation.

14.1 (CMHA). ECCM Devices and Capabilities for NIKE-HERCULES Systems with Anti-Jam Display (AJD)

The ECCM capabilities are greatly increased with the incorporation of the AJD into the NIKE-HERCULES Systems. These systems provide you with a simultaneous display of the outputs of two separate receivers, each of which contains many ECCM features. These receivers are generally referred to as main and strobe. You may also utilize the normal NIKE-HERCULES receiver (with MTI) in which all AJD features are removed. Figure 11.1 illustrates a simplified block diagram of the NAR with AJD. With the addition of the AJD, you are provided many new selective features that will aid you in combatting transmission ECM techniques. You should know which of these features is most effective against a given type of ECM and how these ECCM features can be employed, singly or in combination, to your best advantage. Only the selective features added by the AJD will be discussed in *a* through *c* below. The selective features used prior to the incorporation of the AJD can still be utilized. For this information, refer to paragraph 14.

a. Use of the AJD Switch.

- (1) *OFF position.* In this position the AJD features are removed and the normal receiver (with MTI) is used. For the discussion of this receiver and its ECCM capabilities, refer to paragraph 14.

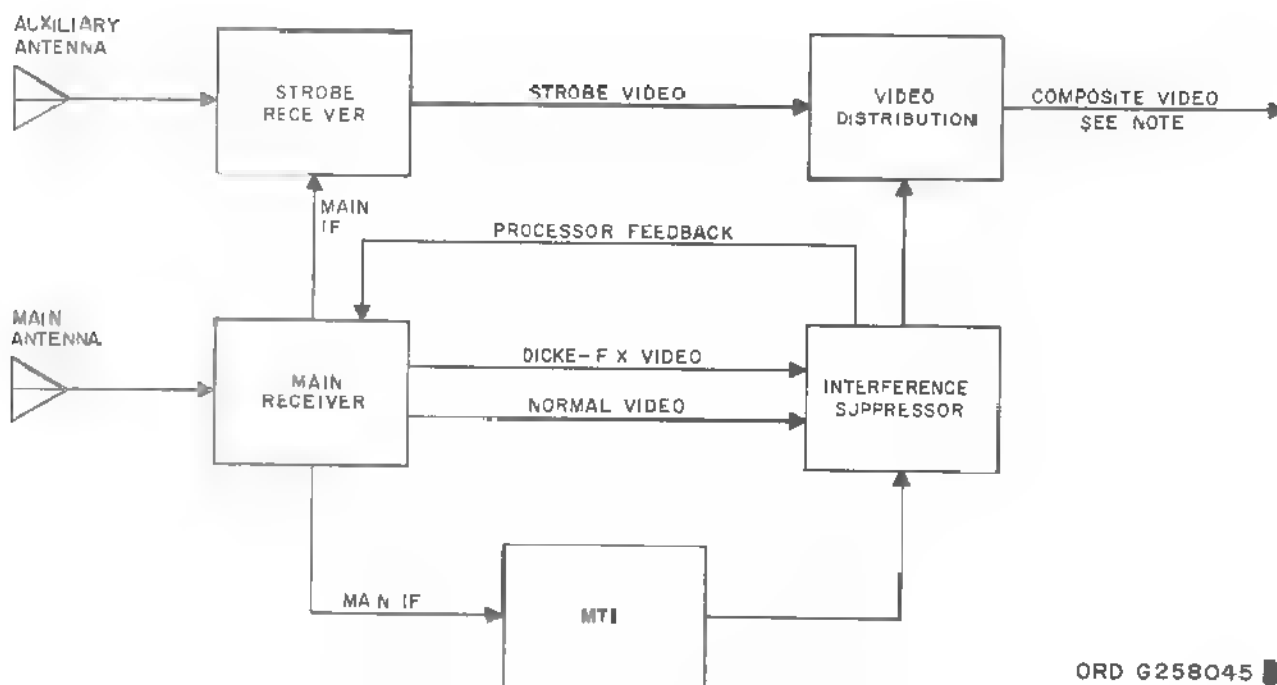
- (2) *On (up) position.* When the AJD switch is set to this position, you can utilize the added AJD features of the NIKE HERCULES acquisition radar. These AJD features, discussed in (a) through (d) below, consist of a Dicke-fix capability, a fast automatic gain control (FAGC), a fast time constant (FTC) action, and a strobe channel.

- (a) *Dicke-fix feature.* The Dicke-fix is an effective means of countering wide-band, noise-modulated jam-

NOTE

TYPES OF VIDEO THAT MAY BE SELECTED

- a. NORMAL VIDEO
- b. NORMAL VIDEO PLUS MTI
- c. INTERFERENCE SUPPRESSOR VIDEO
- d. PROCESSED INTERFERENCE SUPPRESSOR VIDEO
- e. DICKE-FIX VIDEO PLUS JAM STROBE VIDEO
- f. INTERFERENCE SUPPRESSOR DICKE-F X VIDEO PLUS JAM STROBE VIDEO
- g. PROCESSED INTERFERENCE SUPPRESSOR DICKE-FIX VIDEO PLUS JAM STROBE VIDEO
- h. JAM STROBE VIDEO



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Figure 11.1 (CMHA). NAR with AJD, simplified block diagram. (U)

ming and fast swept-frequency jamming and is part of the main receiver. Figure 11.2 shows a simplified block diagram of the NAR Dicke-fix circuit. The Dicke-fix greatly restricts the amount of jamming signal which is passed by the receiver. This is accomplished by high amplification of both the target and jamming signals and

limiting of both these signals to a predetermined level. The amplification and limiting process takes place in two wide-band IF amplifiers which have a bandpass of 10 megacycles. The composite target and jamming signals are then coupled through a narrow-band IF filter which only allows signals within a 1-megacycle band to pass.



Figure 11.2 (CMHA). NAR Dicke-fix circuit, simplified block diagram. (U)

This technique eliminates all undesirable jamming signals occurring outside the 1-megacycle bandpass. Since all signals are limited by the Dicke-fix, the MTI circuits cannot be used; therefore, they are bypassed. The effects of Dicke-fix on wide-band, noise jamming; fast swept-frequency jamming; slow swept-frequency, cw jamming; and spot-frequency, cw jamming are discussed in 1 through 3 below.

1. *Wide-band, noise jamming.* During this type of jamming, when the jamming signal is equal to or somewhat greater than the target signal, the jamming signals should not affect the display of the target signals on your PPI. The only indication of jamming you would have on your PPI would be a jamming strobe at the azimuth of the jammer from the strobe receiver. Figure 11.3 (AJD ON) shows the effects of setting the AJD switch to the on (up) position during a noise jamming environment. The target paint should be visible in the jamming strobe. This is called burnthrough (fig. 11.3). However, if the jamming signal is much stronger than a target return, the target can be masked by the jamming signal and you will not see the target. Targets which present returns at other azimuths will be seen.
2. *Fast swept-frequency jamming.* The effects and operation of a Dicke-fix receiver against this type jammer is dependent on the sweep rate. At a very high sweep rate, the jamming signal appears

to the Dicke-fix receiver as though it were an amplitude modulated CW signal. The effects of this type jamming is discussed in (b) below. At slower sweep rates, not approaching the slow sweep rate, but not at the above discussed very high sweep rate, the Dicke-fix receiver will eliminate the majority of adverse effects. The normal receiver would tend to saturate at these rates, however, the Dicke-fix receiver will produce normal presentation.

3. *Slow swept-frequency and spot-frequency, cw jamming.* The Dicke-fix circuits will aid in eliminating this type of jamming signals, but the FTC circuits are the primary circuits that eliminate these effects. The FTC is discussed in (c) below.
- (b) *FAGC feature.* The FAGC is used to control the gain of the main acquisition IF amplifier at a nearly constant noise level. Figure 11.4 shows a simplified block diagram of the NAR FAGC circuit. The FAGC and the main acquisition IF amplifier form a gain controlled loop. The FAGC signal from the fast AGC amplifier is applied to the main acquisition IF amplifier to establish the quiescent over-all gain of the main acquisition IF amplifier. Any reduction in the noise output of the main acquisition IF amplifier is representative of the reduction of signal input such as caused by cw jamming, resulting in a decrease in the FAGC signal. The reduced FAGC signal results in an increase in the gain of the main acquisition

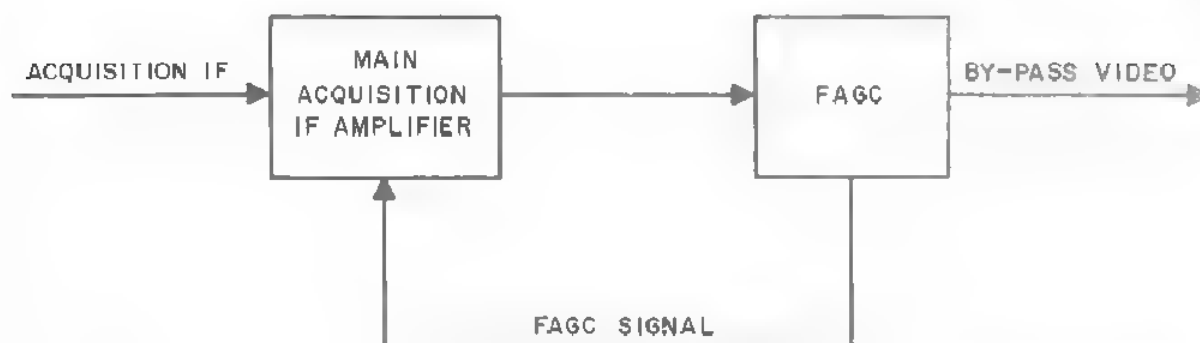


Figure 11.3 (CMHA). Effects of AJD features during a noise type jamming environment. (U)

IF amplifier and a boost in the signal strength of weak target return signals. The FAGC circuit in combination with the Dicke-fix receiver is very effective against spot-frequency, cw jamming. It also has desirable effects against slow swept jamming due to its fast time con-

stant (FTC) capability, which is discussed in (c) below. The FAGC removes the effects of jamming signals that are in the wideband amplifier bandpass but are not in the bandpass of the narrow-band IF filter or the main acquisition IF amplifier.

(c) *FTC feature.* This ECCM feature



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Figure 11.4 (CMHA). NAR FAGC circuit, simplified block diagram. (U)

is a part of the fast AGC amplifier. The FTC circuit reduces signals that are of longer duration than those of target signals. Since cw jamming provides a long duration signal, the FTC technique is very effective in reducing the duration of cw jamming signals, causing the jamming effects to diminish. The FTC ECCM capability is an effective means of combatting on-frequency, cw jamming and reflective jamming. When the jammer frequency is within the bandpass of the narrow-band IF filter or main acquisition IF amplifier, a strobe will be presented on the PPI at the azimuth of the jamming source. It is possible that you will see a multiple strobe, but this depends on the power output of the jammer. If the jammer frequency is not within the bandpass of the wide-band amplifier, normal target video will be presented on the PPI. The FTC circuit is equally effective in breaking up a chaff stream presentation on the PPI.

- (d) *Strobe channel feature.* The purpose of the strobe receiver is to provide you with a jamming strobe at the azimuth of any noise or cw transmission jammer on the PPI. This is done without degrading or distracting from the target informa-

tion. The strobe channel operates on a reception principle only. The strobe channel will receive inputs from most reflected transmitted signals and any transmission jamming provided these jamming signals are in the bandpass of the strobe receiver. Figure 11.5 shows a simplified block diagram of the NAR strobe channel. Electrically, the strobe and main receivers are identical prior to the IF coupler. The inputs to the IF coupler are an auxiliary IF signal and a main IF signal. The IF coupler combines the two signals. The stronger of the two inputs will predominate in the output of this stage. The auxiliary signal will be greater than the main signal at all azimuth angles other than that of the main acquisition antenna's main lobe. Therefore, strobe video will be displayed at those azimuths where the main lobe of the main acquisition antenna encounters a jamming signal. It is possible that you may see the target in the strobe. In this case, the reflected target signal is stronger than the jamming signal and will be displayed as a bright area in the strobe. By using normal methods, you can designate the jamming target in range and azimuth. If the

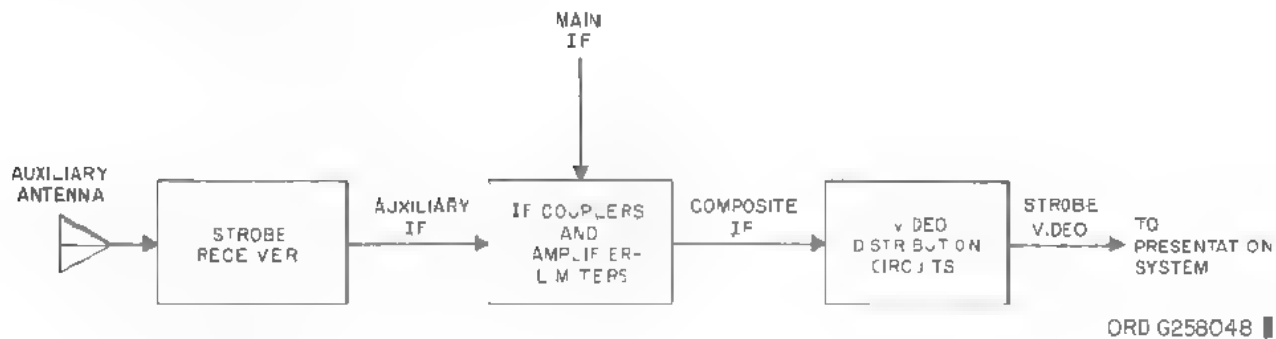


Figure 11.5 (CMHA). NAR strobe channel, simplified block diagram. (U)

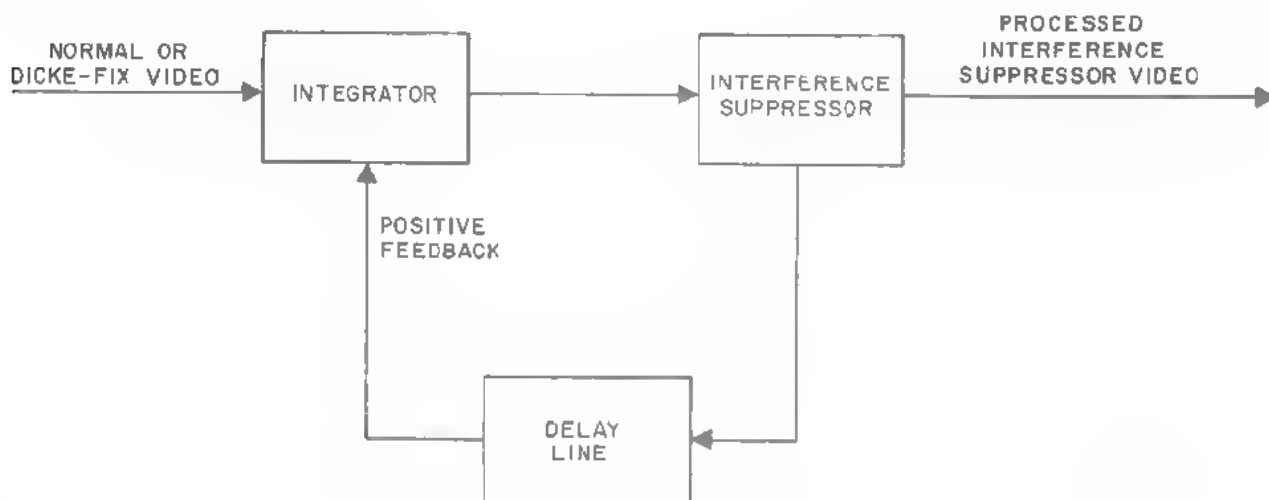
target is masked by the jamming signal, only the azimuth of the jamming source can be designated to the target tracking radar.

b. Use of the PROC-IS switch.

- (1) *OFF position.* In this position the AJD features are removed and the normal receiver (with MTI) is used. For the discussion of this receiver and its ECCM capabilities, refer to paragraph 14.

- (2) *IS position.* For the discussion of the IS position, refer to paragraph 14f.

- (3) *PROC position.* The PROC position is used to increase the capability of detecting weak video signals by increasing the target amplitude, and limiting the noise amplitude to a preset level. This circuit operates on a positive feedback principle. Figure 11.6 shows a simplified block diagram of the processing circuit. Normal or



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Figure 11.6 (CMHA). Processing circuit, simplified block diagram. (U)

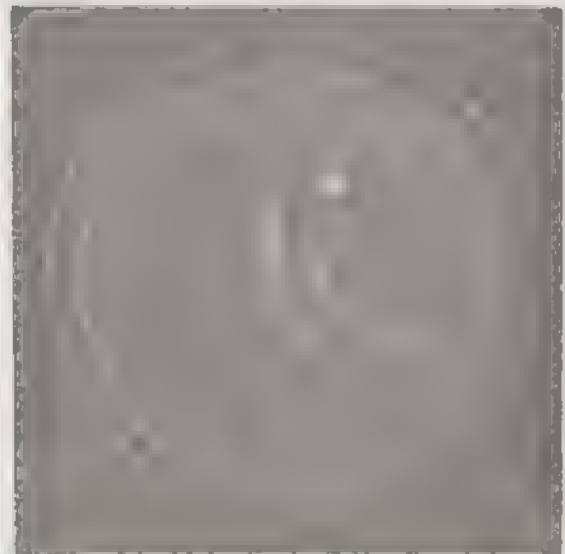
Dicke-fix video is applied to the processing circuit and delayed one prf, amplified, and returned for addition to the next prf video pulse. Since the target signals are coincident, they are added. Noise or nonsynchronous jamming signals would appear at random times and would not increase in amplitude. Figure 11.3 shows a sequence using the AJD capability and then the AJD with the processor. You will notice that when the processor is used, video appears brighter on the PPI. This capability is very effective against noise jamming, cw jamming, and random pulse jamming.

c. *Use of JS ONLY Switch.* When the JS ONLY switch is operated to the on (up) position, the only signal seen on your PPI will be strobe video. The main or Dicke-fix video is removed in the main receiver. Figure 11.7 shows the effects of operating the JS ONLY switch to the on (up) position.

d. *Use of RECEIVER-GAIN Knob Maximum Clockwise (In AGC).* When the RECEIVER-GAIN knob is rotated maximum clockwise (in AGC) past the first positive stop, the normal receiver can be used as a fixed gain receiver using only the FAGC feature of the AJD receiver. Figure 11.8 shows a simplified block diagram of the effects of rotating the RECEIVER-GAIN knob maximum clockwise. In this position a fixed bias is applied to the main IF pre amplifier that establishes maximum gain to the main IF signals. At the same time a relay ground is applied to the fast AGC amplifier which applies the FAGC voltage to the main acquisition IF amplifier. For the effects of this FAGC voltage, refer to the discussion in a(2)(b) above. The output video, with the FAGC action, is applied to the video distribution circuits for distribution to the presentation system. Figure 11.9 shows the effects of rotating the RECEIVER-GAIN knob maximum clockwise

15 (CMHA). General Operating Principles

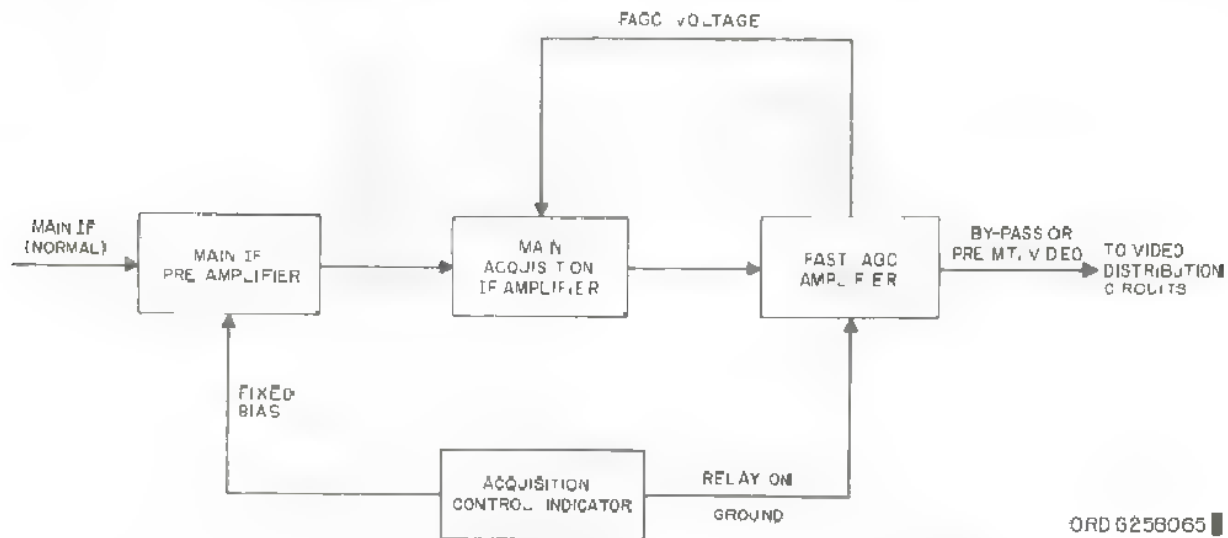
The following principles of operation, though not restricted to ECCM operation, are of particular importance when you are operating the acquisition radar in an ECM environment.



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■ Figure 11.7 (CMHA). Effects of setting JS ONLY switch to on (up) position. (U)

a. If you employ automatic elevation scan when searching for a target, switch from automatic control to manual control as soon as a target is detected. With manual control you can assure optimum display of possible targets. It is especially important that you provide maximum illumination of the target on the PI's



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Figure 11.8 (CMHA). Receiver circuit with RECEIVER-GAIN knob maximum clockwise (in AGC), simplified block diagram. (U)

when transferring target information to the target tracking radar.

b. Another factor to be kept in mind when transferring a target to the target tracking radar is the rate of rotation of the antenna. During the search for targets, antenna rotation

may be slow (10 rpm for NIKE-AJAX and 5 rpm for NIKE-HERCULES). Once the target is designated to the target tracking radar, antenna rotation should be increased to increase the data rate without losing target visibility.

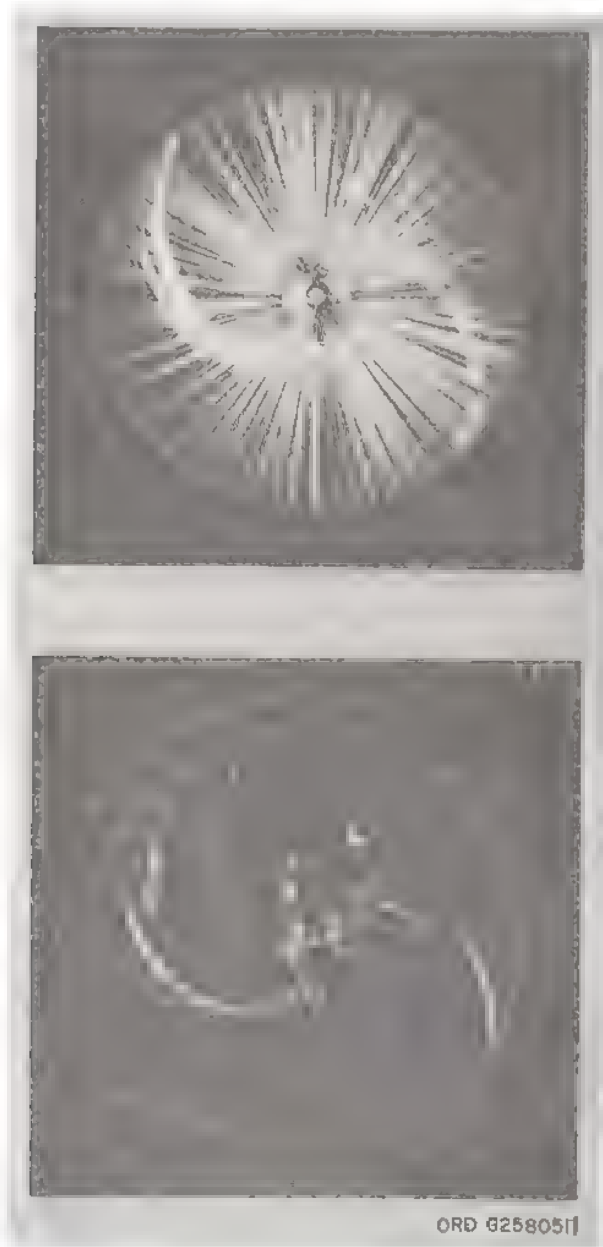


Figure 11.9 (CMHA). Effects of rotating RECEIVER-GAIN knob maximum clockwise (in AGC) (U)

Section 1.1 (CMHA). ACQUISITION RADARS (IMPROVED NIKE-HERCULES RADAR SYSTEMS)**15.1 (CMHA). General**

This section describes the ECCM devices and capabilities of the Improved NIKE-HERCULES (INH) acquisition radars and provides general operating principles in an ECM environment. This information is directed primarily to the acquisition operator of an INH system with both S-band and L-band acquisition radars. The S-band radar of the INH system is identical to the NIKE-HERCULES acquisition radar system. For coverage of the S-band radar, refer to paragraphs 11 through 15. The S-band radar system, used in conjunction with the L-band radar system, provides a choice of radar systems each of which contains many selective and nonselective ECCM features capable of combatting severe ECM tactics. You should know which of these features is most effective against a given type of ECM and how these ECCM features can be employed, singly or in combination, to your best advantage. For a discussion of ECM environment and ECM analysis and reporting, refer to paragraphs 12 and 13, respectively.

15.2 (CMHA). ECCM Devices and Capabilities

The high power acquisition radar (HIPAR) system with antijam display (AJD) provides you with a simultaneous display of the outputs of two separate receivers which contain many ECCM features. These receivers are generally referred to as main (with MTI) and strobe. Figure 11.10 shows a simplified block diagram of the HIPAR with AJD. The video you see on the indicator is a composite video consisting of a combination of coherent (coho) video, integrated (INT) video and/or noncoherent (noncoho) video. For the discussion of the scope patterns, refer to a(4)(a) below. The purpose of the main receiver, also referred to as target receiver, is to reject jamming signals and provide you with only target information on the PPI and PI. The MTI, including both coho and noncoho channels, cancels ground and random clutter (chaff, rope, corner reflectors, clouds, etc.), rejects jamming signals, and provides target information to the indicators. Although the main receiver (with MTI) provides

target information and rejects received jamming signals, it cannot portray targets which are being masked by jammers. Therefore, a second receiver is necessary to disclose the position of existing jammers. This is accomplished by the strobe receiver which provides you with an azimuth strobe line on the indicators, coincident with the azimuth of each jammer. The output of the strobe receiver is superimposed, at a reduced intensity level, upon the main receiver portion of the acquisition presentation. This composite presentation of main and strobe receivers provides you with a display which portrays target information, cancelled ground and random clutter, and indication of jammer azimuth. This is accomplished automatically with a minimum of switching, thus allowing you to operate at maximum efficiency. You should be free to devote your full time to the detection, evaluation, and designation of the enemy targets in an ECM environment. There are some ECCM controls and features of the HIPAR, other than the built-in features, which have a particular significance in ECCM operation. These selective and nonselective devices and features are discussed in a and b below.

a. Selective ECCM Devices and Capabilities.

- (1) *Plan position indicator (PPI) and precision indicator (PI).* The focus, intensity, and video gain controls for the PPI and PI should be adjusted according to normal adjustment procedures for optimum presentation on the indicators. Once these adjustments are made, they should not be readjusted when operating against ECM.
- (2) *Expanded sweep.* Refer to paragraph 14g.
- (3) *Aided range operation.* Refer to paragraph 14e.
- (4) *Use of RECEIVER switch.*
 - (a) *NORMAL position.* When you select this position, all of the nonselective ADJ features of the HIPAR are utilized and the selective features may be used, singly or in combination, to allow you to operate at maximum efficiency.

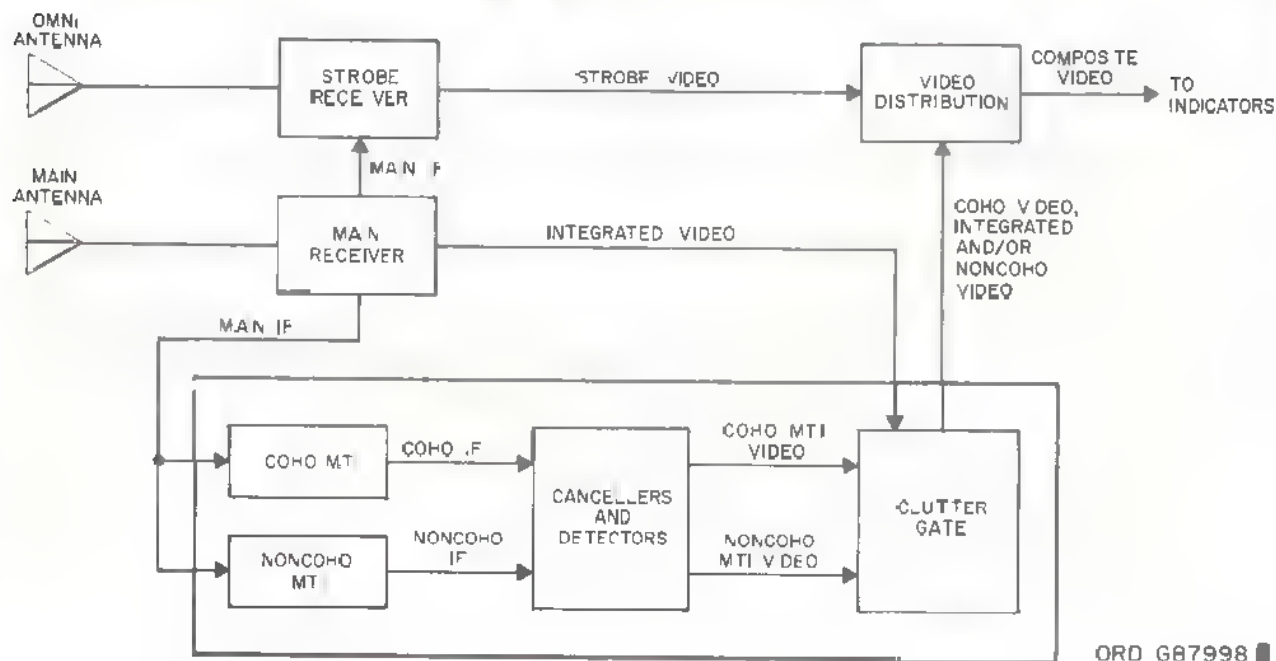


Figure 11.10 (CMHA). HIPAR with AJD, simplified block diagram. (U)

- (b) **EMERGENCY position.** In this position all of the AJD features of the HIPAR are removed and you are provided with the capability of manually controlling the HIPAR receiver gain. Decreasing the receiver gain reduces received transmission jamming and presents only a narrow jamming strobe on the indicator. You should notice as you decrease the gain of the receiver that all presentation on the indicator is reduced. Figure 11.11 shows these effects. This feature should only be used during an engagement as an emergency means when saturation occurs in the AJD receiver.
- (5) **Use of CLUTTER GATE switch.**

Note. The key numbers shown in parentheses in (a) below refer to figure 11.12

- (a) **NORMAL position.** Figure 11.12 shows the normal presentation pattern using clutter gating. The areas of presentation from the center of the scope are coho MTI video (6), integrated video (3), and noncoho MTI video (5). The length of the strobe video (1) is controlled by the

adjustment of the strobe range gate (2). The area of coverage of the coho MTI is controlled by the adjustment of the MTI range gate (7). Any random clutter (4) would be greatly reduced by the clutter gating action. The presentation you see on the scope as the result of clutter gating is shown as noncoho MTI video (5). Therefore, the HIPAR system with AJD will present to you a composite video presentation on the scope.

- (b) **ALL RANGE position.** In this position, the coherent MTI video is replaced by integrated normal video or clutter gated noncoherent MTI video. You can use this position to remove the effects of chaff in the coherent MTI area. Figure 11.13 shows the effects of removing the clutter presentation from the coho area by using the ALL RANGE position of the CLUTTER GATE switch.
- (c) **OFF position.** In this position the clutter gating is removed and the main receiver fast automatic gain



Figure 11.11 (CMHA). Effects of reducing receiver gain with RECEIVER switch in EMERGENCY position to obtain main jamming strobe. (U)

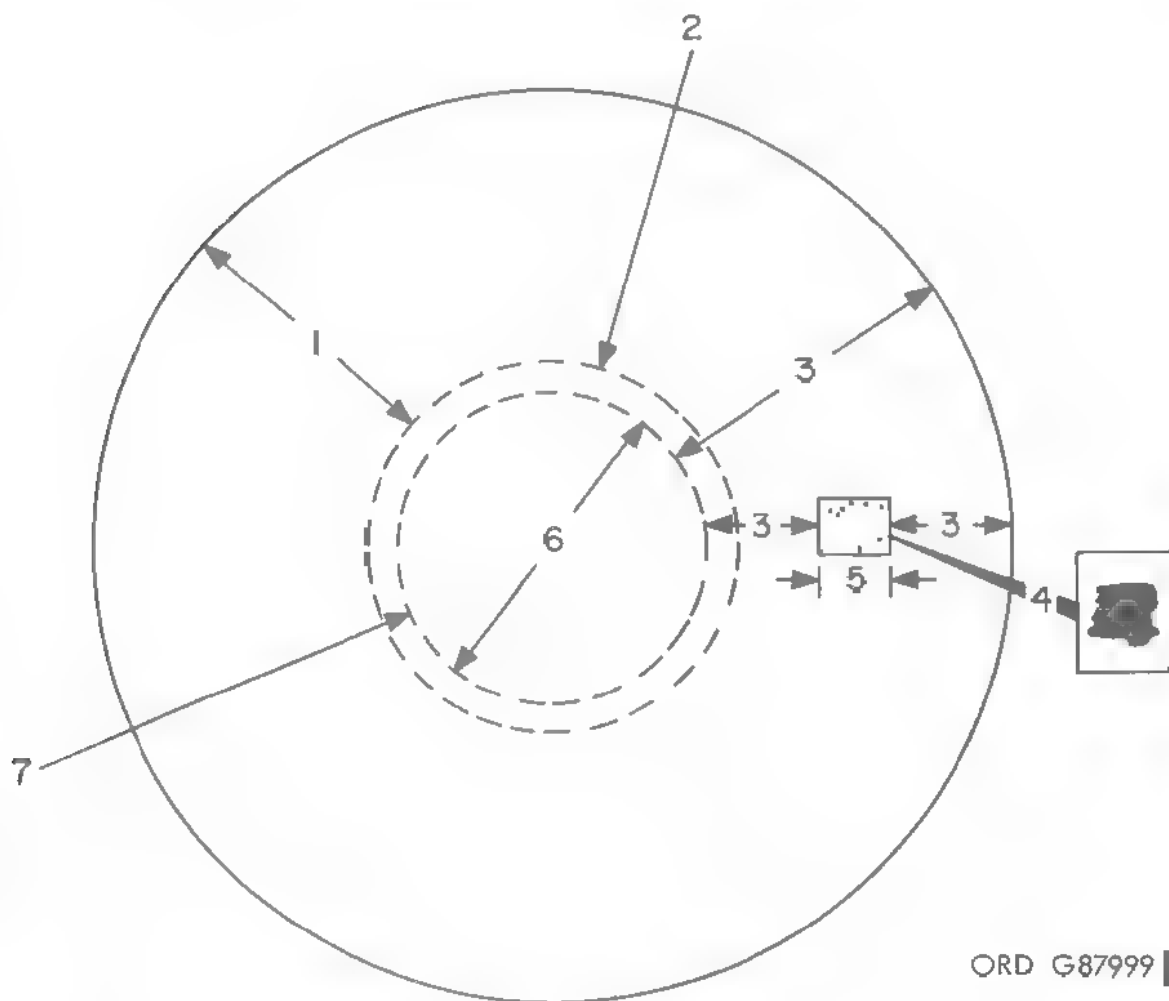
control (FAGC) is energized. This method of operation is very effective against a jamming frequency within the wide bandpass but not in the narrow bandpass of the receiver. The effects of this jamming would cause quieting (cw capture) of the targets and clutter in the normal receiver area. Figure 11.14 shows the effects of this capture and the results of setting the CLUTTER GATE switch to OFF.

(6) Use of DISPLAY switch.

(a) *NORMAL position.* In this position the stagger prf feature is used. The stagger circuits are used to vary the time intervals between transmitted pulses. This type of transmission eliminates an undesirable MTI problem and aids in preventing an enemy jammer from locking on your prf. The video presentation you will see will be strobe video and Dicke-fix video.

(b) *STROBE ONLY position.* In this position the outputs of the main receiver are removed and only the output of the strobe receiver will be presented on the indicators. In a transmission ECM environment which causes multiple strobes you may be required to use this position. Figure 11.15 shows the effects of placing the DISPLAY switch to STROBE ONLY. You will see a strobe from each jammer and reflected returns from ground clutter and large targets beyond the strobe range gate setting.

(c) *STAGGER OFF position.* When you set the DISPLAY switch to this position, the stagger prf feature is removed and the transmitting system assumes a constant prf mode of operation. In a transmission ECM environment used to confuse or deceive you, such as spoofers, the use of the constant prf mode of operation will enable you to identify the targets from the spoofers. Figure 11.16 shows spoofers on your indi-



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- 1—Strobe video area
- 2—Strobe range gate
- 3—Integrated video
- 4—Random clutter (not gated)

- 5—Noncoho MTI video area (clutter gated)
- 6—Coho MTI video area
- 7—MTI range gate

Figure 11.12 (CMHA). Normal presentation pattern using clutter gating. (U)

cator and the effects of switching to STAGGER OFF. In the stagger prf mode each spoofer will be presented as a pair slightly separated in range. A target will always present only one return in the stagger prf mode or in the constant prf mode. Switching to the STAGGER OFF position will present only one spoofer, not a pair. By alternately switching between STAGGER OFF and NORMAL you can determine which of these returns are targets.

(7) *Radar select and frequency tuning capabilities.* The INH system provides you with a choice of two acquisition radars. The HIPAR and low power acquisition radar (LOPAR) systems used in conjunction provide you with an over-all system capability of tuning through two frequency bands. This combination provides you with the capability of selecting the radar system and frequency that are least affected by transmission ECM techniques.

the HIPAR main receiver. The Dicke-fix used in conjunction with the FAGC will be discussed in (2) below. The Dicke-fix greatly restricts the amount of jamming signal which is passed by the receiver, while offering negligible



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Figure 11.13 (CMHA). Effects of setting CLUTTER GATE switch to ALL RANGE position with chaff in echo MTI area. (U)

b. Nonselective ECCM Devices and Capabilities.

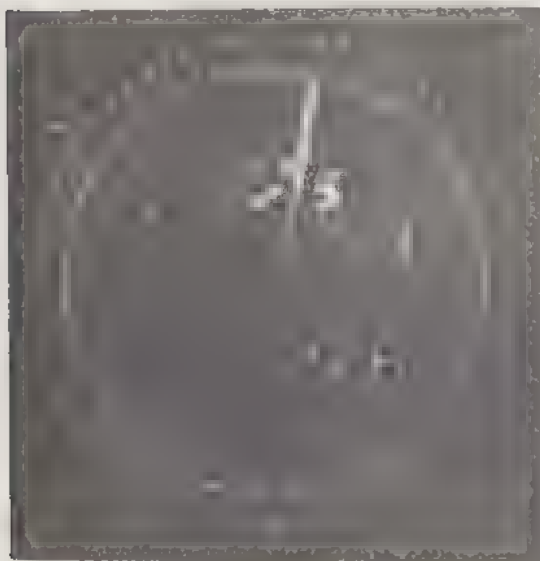
- (1) *Dicke-fix*. The Dicke-fix is an effective means of countering wide-band, noise-modulated jamming and fast swept-frequency jamming; and is part of



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Figure 11.14 (CMHA). Effects of setting CLUTTER GATE switch to OFF position to combat cw capture-type jamming. (U)

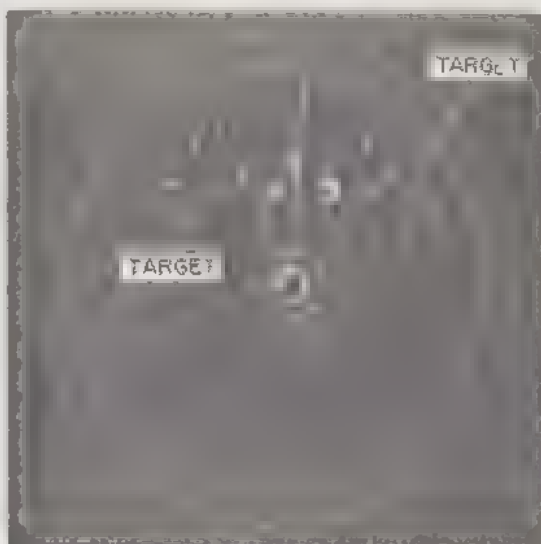
nals to the same predetermined level and passing the composite target and jamming signals through a filter network which allows only signals within a 200-kilocycle band to pass. This technique eliminates all undesirable



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Figure 11.15 (CMHA). Effects of setting DISPLAY switch to STROBE ONLY position to combat multiple strobes. (U)

restriction to the target. Figure 11.17 shows a simplified block diagram of the HIPAR Dicke-fix effect. This is accomplished by high amplification of both target and jamming signals, limiting the jamming and target sig-



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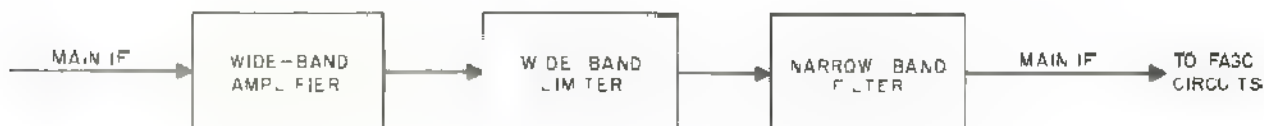
Figure 11.16 (CMHA). Effects of setting DISPLAY switch to STAGGER OFF position to combat spoofers. (U)

jamming signals occurring outside the 200-kilocycle bandpass. The effects of Dicke-fix on wide-band, noise jamming; fast swept-frequency jamming; slow swept-frequency, cw jamming; and spot-frequency, cw jamming are discussed in (a) through (c) below.

- (a) *Wide-band, noise jamming.* During wide-band, noise jamming, when the target signal is equal to or somewhat greater than the jamming signal, the jamming signals should not affect the display of the target signals on the PPI. This is called target burnthrough (fig. 11.3). If the target is in the strobe, the target will appear brighter than the strobe. However, if the jamming signal is much stronger than a target return at the same azimuth, the target will be masked by the jamming signal and you will not see the target. Targets which present returns at other azimuths will be seen.
- (b) *Fast swept-frequency jamming.* The effects and operation of a Dicke-fix receiver against this type jammer is dependent on the sweep rate. At a very high sweep rate, the jamming signal appears to the Dicke-fix receiver as though it were an amplitude modulated CW signal. The effects of this type jamming is discussed in (a) below. At slower sweep rates, not approaching the slow sweep rate, but not at the above discussed very high sweep rate, the Dicke-fix receiver will eliminate the majority of adverse affects. The normal receiver would tend to saturate at these rates, however, the

Dicke-fix receiver will produce normal presentation.

- (c) *Slow swept-frequency and spot-frequency, cw jamming.* The Dicke-fix circuits will aid in eliminating these types of jamming signals but the FTC circuit is the primary circuits that eliminate these effects. The FTC is discussed in (3) below.
- (2) *FAGC capability.* The FAGC circuit is used to control the gain of the narrow-band amplifiers. Figure 11.18 shows a simplified block diagram of the HIPAR FAGC circuit. The fast AGC amplifier in conjunction with the signal detector and narrow-band amplifiers forms a FAGC control loop. The purpose of the FAGC amplifier is to control the narrow-band amplifiers so as to maintain a nearly constant noise level output. The FAGC signal applied to the narrow-band amplifiers, from the FAGC amplifier, establishes the quiescent over-all gain of the narrow-band amplifier. Any reduction in the noise output of the narrow-band amplifier is representative of the reduction of signal input such as caused by cw jamming, resulting in a decrease in the FAGC signal. The reduced FAGC signal results in an increase in the gain of the narrow-band amplifiers and a boost in the signal strength of weak target return signals. The FAGC circuits are very effective against slow swept-frequency and spot-frequency, cw jamming. The FAGC removes the effects of jamming signals that are within the wide-band amplifier bandpass but not in the narrow-band amplifier bandpass.



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■ Figure 11.17 (CHMA). HIPAR Dicke-fix, simplified block diagram (U)

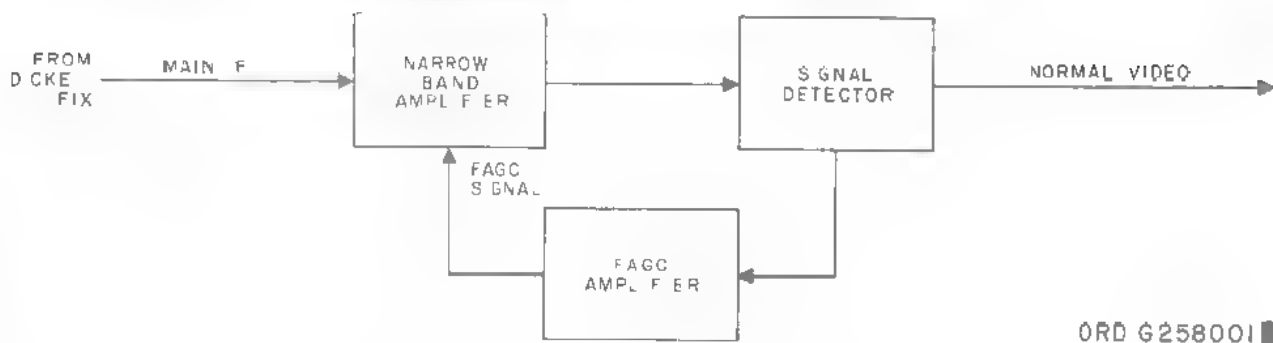


Figure 11.18 (CMHA) HIPAR FAGC circuit, simplified block diagram. (U)

(3) *Fast time constant (FTC) capability.*

This ECCM feature is a part of the main receiver. The FTC circuit reduces signals that are of longer duration than that of a target signal. Since cw jamming provides a long duration signal, the FTC technique is very effective in reducing the duration of cw jamming signals, causing the jamming effects to diminish. The FTC ECCM capability is an effective means of combatting on-frequency, cw jamming and reflective jamming. When the jammer frequency is within the bandpass of the narrow-band amplifier, a strobe will be presented on the PPI at the azimuth of the jamming source. It is possible that you will see a multiple strobe, but this depends on the power output of the jammer. If the jammer frequency is not within the bandpass of the wide-band amplifier, normal target video will be presented on the PPI. The FTC circuit is equally effective in breaking up a chaff stream presentation on the PPI.

(4) *Stagger prf capability.* The stagger

prf of the HIPAR provides you with a continuous variation of the transmitter prf. This capability is very effective against transmission deception ECM techniques. Due to the stagger prf mode of operation, false target video signals, generated by the transmission deception devices, appear as two separate targets slightly separated in range on your PPI indicator. Actual target video signals appear as one target. Setting the DISPLAY switch to STAGGER OFF will remove the stagger prf feature and the transmitting system will assume a constant prf mode of operation and only one false target would appear. By alternately switching the DISPLAY switch between STAGGER OFF and NORMAL, you can determine which of the returns are the real targets.

(5) *Video integration capability.* The video integrator is used to increase the capability of detecting weak video signals, increasing the target amplitude and limiting the noise amplitude to a preset level. It operates on a positive

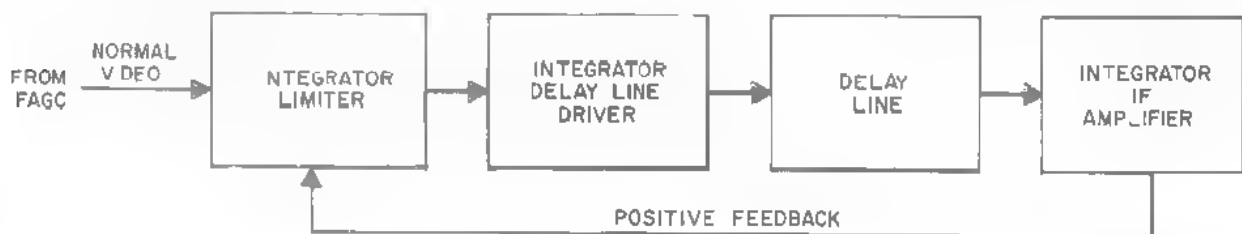


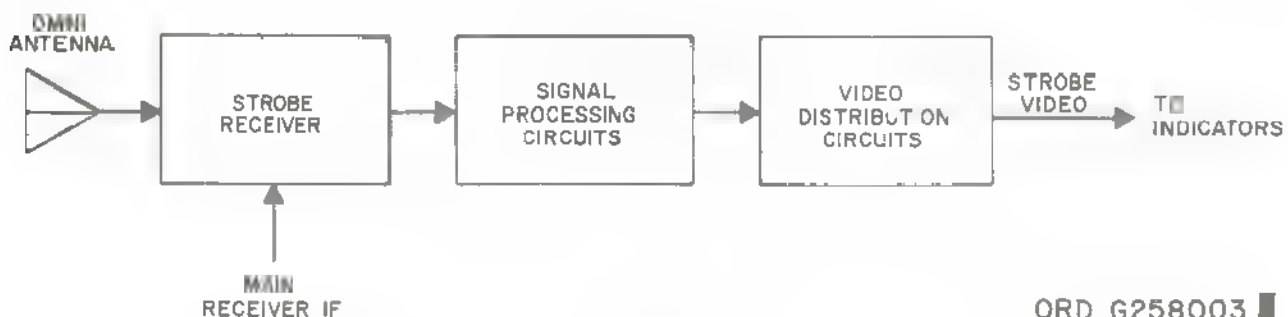
Figure 11.19 (CMHA). Video integrator, simplified block diagram. (U)

feedback principle. Figure 11.19 shows a simplified block diagram of the video integrator. Normal video is applied to the integrator circuit, delayed one prf, amplified, and returned for addition to the next prf video pulse. Since the target signals are coincident, they are added. Noise or nonsynchronous jamming signals would appear at random times and would not increase in amplitude. This capability is very effective against noise jamming, cw jamming, and random pulse jamming.

- (6) *Strobe line capability.* The strobe line capability provides you with the means to engage the jamming target even though the jamming signals are much stronger than the target return signal. The strobes that you see on the PPI represent the azimuth of the jamming source and with this information you can designate the strobe to the target tracking radar system. As the jamming target range decreases, it is possible that you may see the target in the strobe. In this case, the reflected target signal is stronger than the jamming signal. This is called target burnthrough. It appears on the scope as a brighter area in the strobe area. By using normal methods, you can designate the jamming target in range. The strobe channel consists of an omni antenna, strobe receiver signal processing circuits, and video distribution circuits. Figure 11.20 shows a simplified block diagram of the HIPAR strobe channel.

- (7) *MTI capability.* The purpose of the HIPAR system MTI is to distinguish between fixed target signals and moving target signals. The MTI system consists of two types of operation, noncoho MTI and coho MTI.

- (a) *Noncoho.* The noncoho MTI operates on an amplitude comparison method. Moving targets in the presence of clutter will produce variable amplitude signals, while clutter or fixed targets produce constant amplitude signals. The constant amplitude signals are cancelled in the MTI system, while the variable amplitude signals are processed for display on the PPI. This is done by a delay and amplitude-comparison process that delays each signal by one pulse repetition time and compares it with the immediately succeeding pulse. At the comparison point, only the difference between the amplitudes of the compared signals are not cancelled. When chaff is dispensed by an aircraft, chaff normally spreads out and drifts in the air. Since the dispersed chaff stream appears to the noncoho MTI as a large stationary target, most of the chaff returns are eliminated. You will also find that the noncoho MTI is very effective in reducing the signal intensity of cw jamming.
- (b) *Coho MTI.* Coherent MTI operates on the phase difference principle. The coho MTI uses the coherent os-



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■ Figure 11.20 (CMHA) HIPAR strobe channel, simplified block diagram. (U)

cillator to generate the reference. The coho MTI, as presented on the PPI, is adjustable in range. Normally, the coho MTI operation is adjusted in range to cover only the local clutter area in order to cancel or reduce the returns from nearby stationary objects.

- (8) *Clutter gate capability.* The clutter gate receives integrated video signals from the main receiver, and coho and noncoho MTI video from the MTI. To eliminate close-in clutter, coho MTI video is passed, unchanged, to the presentation circuit. This unchanged coho MTI presentation is limited to the pre-adjusted MTI range gate area. For noncoho MTI signals to be applied to the PPI, the integrated signals from the main receiver must be of a duration longer than 9 microseconds. When a video signal is longer than 9 microseconds in duration, the noncoho MTI output of the clutter gate circuits will replace the integrated video from the main receiver during these periods.

Figure 11.21 shows a simplified block diagram of the clutter gate action. For the PPI scope patterns refer to figure 11.12. The clutter gating effect is controlled by the **CLUTTER GATE** switch. For the effects of setting this switch to the **NORMAL**, **OFF**, and **ALL RANGE** positions, refer to a(5) above.

15.3 (CMHA). General Operating Principles

The following principles of operation, though not restricted to ECCM operation, are of particular importance when you are operating the acquisition radars in an ECM environment. For the discussion of the LOPAR general operating principles refer to paragraph 15.

a. During an ECM environment it is important that you engage your target at the earliest opportunity. The maximum range presentation should be used.

b. Another factor to be kept in mind is speed of rotation of the antenna. The 10 rpm position should provide you with the best results and over-all data rate.

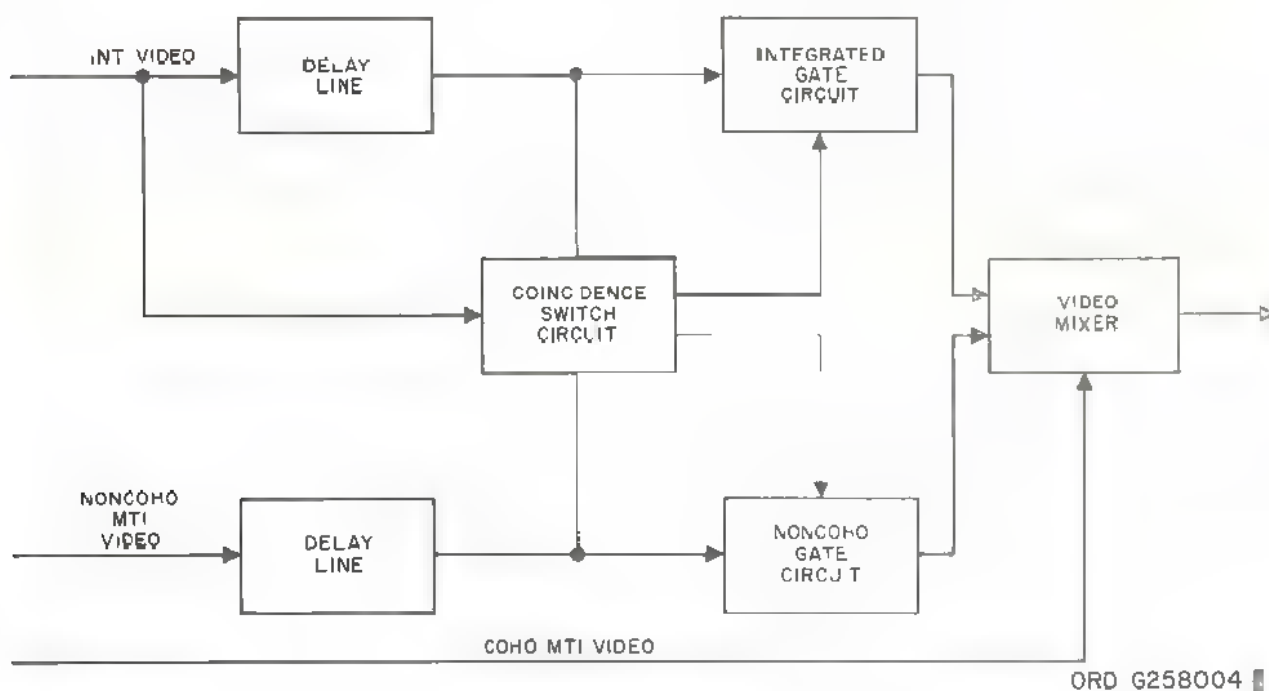


Figure 11.21 (CMHA). Clutter gate circuit, simplified block diagram. (U)

Section I.2 (CMHA). ACQUISITION RADARS (NIKE-HERCULES ANTI-TACTICAL BALLISTIC MISSILE SYSTEMS)**15.4 (CMHA). General**

This section describes the ECCM devices and capabilities of the NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) acquisition radars and provides you with general operating principles in an ECM environment. This information is directed primarily to the long range (LR) operator and the short range (SR) operator. Both L-band and S-band acquisition radars are used in the NIKE-HERCULES ATBM System. This system provides you with a choice of radar systems, operating in two separate frequency bands; an indicator system capable of displaying, simultaneously, the presence of long-range and short-range targets; a selection of any of six receiver modes of operation; and many other selective and nonselective ECCM features you may use to combat severe ECM tactics. You should know which of these features is most effective against a given type of ECM and how these ECCM features can be employed, singly or in combination, to your best advantage. For a discussion of ECM environment and ECM analysis and reporting, refer to paragraphs 12 and 13, respectively. For LOPAR/HIPAR ECCM devices and capabilities of the ATBM system, refer to paragraph 15.5. For LOPAR ECCM devices and capabilities of the ATBM system, refer to paragraph 15.6, and for the EFS/ATBM HIPAR systems, refer to paragraph 15.7. For general operating principles of the ATBM system, refer to paragraph 15.8.

15.5 (CMHA). LOPAR/HIPAR ECCM Devices and Capabilities of the ATBM System

The presentation system of the ATBM system provides you with two separate PPI displays. These PPI's, the long range (LR) PPI and short range (SR) PPI, are used with both the HIPAR and LOPAR systems. Selection of the HIPAR or LOPAR video is accomplished by both the LRSA and SRSA operators simultaneously depressing either the VIDEO SELECTED—HIPAR READY or VIDEO SELECTED—LOPAR READY switch-indicators on the HIPAR and LOPAR control-indicators.

Once the desired video display is selected, either operator may preview the video from the non-selected radar by depressing the nonselected switch-indicator. This provides you with the capability of observing the ECM effects on both the HIPAR and LOPAR simultaneously, and permits the selecting of the radar system that is least affected by transmission ECM techniques. Should you determine that the nonselected radar system is least affected, the desired VIDEO SELECTED switch-indicators on the HIPAR and LOPAR control-indicators are depressed simultaneously.

15.6 (CMHA). LOPAR ECCM Devices and Capabilities of the ATBM System

The LOPAR system provides you with a simultaneous display of the outputs of two separate receivers which contain many ECCM features. The receivers are the AJD RECEIVER (main) and JS ONLY RECEIVER (strobe). Figure 11.1 is a simplified block diagram of an NAR which is functionally identical to the LOPAR of the ATBM system. When the LOPAR is selected, the display seen on the LR and SR PPI's is a composite video consisting of a combination of Dicke-fix plus jam strobe video, interference suppressor Dicke-fix video plus jam strobe video, or processed interference suppressor Dicke-fix video plus jam strobe video. The purpose of the main receiver is to reject jamming signals and to provide you with only target information on both PPI's. Although the AJD RECEIVER provides target information and rejects received jamming signals, it cannot portray targets which are being masked by jammers. Therefore, a second receiver is necessary to disclose the position of existing jammers. This is accomplished by the strobe receiver which provides you with an azimuth strobe line on the PPI's coincident with the azimuth of each jammer. The output of the strobe receiver is superimposed, at a reduced intensity level, upon the AJD portion of the acquisition presentation. This composite presentation of main and strobe receivers provides you with a display which portrays target in-

formation, cancelled ground and random clutter, and indication of a jammer azimuth. This is accomplished automatically with a minimum of switching, thus allowing you to operate at maximum efficiency. A third receiver, BASIC RECEIVER, also provides you with the capability of operating the LOPAR system as a manual gain receiver. This allows the operation of the GAIN—AGC control on the LOPAR control-indicator and the MTI system. For a discussion of the MTI, refer to paragraphs 14c and 15.6a(5) and for the GAIN—AGC control, refer to paragraphs 15.6a(2)(c) and 15.6a(7). You should be free to devote your full time to the detection, evaluation, and designation of the enemy targets in an ECM environment. There are some ECCM controls and features of the LOPAR, other than the built-in features, which have a particular significance in ECCM operation. The LOPAR selective and nonselective devices and features are discussed in *a* and *b* below.

a. LOPAR Selective ECCM Devices and Capabilities.

- (1) *PPI indicators.* The VIDEO GAIN control on both the LR and SR PPI's should be adjusted according to normal adjustment procedures for optimum presentation on the indicators. Once these adjustments are made, controls should not be readjusted when operating against ECM. During BASIC RECEIVER operation only, the gain adjustment used against ECM should be an adjustment of receiver gain, not indicator video gain. To change the persistency of the video display, the LONG PERST—SHORT PERST and ERASE switch-indicators may be used. Special instructions concerning indicator observation in the presence of certain types of ECM are presented in Chapter 3.

- (2) *LOPAR receiver selection.*

- (a) *AJD RECEIVER switch-indicator.* When the AJD RECEIVER switch-indicator on the LOPAR control-indicator is illuminated (green), the AJD features of the LOPAR system are utilized and the MTI features are removed. For a dis-

cussion of the nonselective AJD features, refer to paragraph 14.1a(2)(a) through (d). When the AJD receiver is in use, you may select IS video or PROC video for display on your PPI's. For a discussion of IS and PROC video, refer to paragraphs (3) and (4) below.

- (b) *JS ONLY RECEIVER switch-indicator.* When the JS ONLY RECEIVER switch-indicator on the LOPAR control-indicator is illuminated (green), the output of the main receiver is removed, and only the output of the strobe receiver will be presented on your PPI's. In a transmission ECM environment which causes multiple strobes, through the main receiver you may be required to use this position. Figure 11.7 shows the effects of depressing the JS ONLY RECEIVER switch-indicator, which is functionally the same as in prior NIKE-HERCULES and INH systems with AJD capabilities.

- (c) *BASIC RECEIVER switch-indicator.* When the BASIC RECEIVER switch-indicator on the LOPAR control-indicator is illuminated (green), the AJD features are removed, and the gain of the receiver is controlled by the GAIN—AGC knob. For a discussion of the effects of rotating the GAIN—AGC knob when GAIN indicator is illuminated (white), refer to discussion in paragraph 14b, of RECEIVER GAIN control, which is functionally the same as in prior NIKE-HERCULES and INH systems with AJD capabilities. For the discussion of the GAIN—AGC knob (in AGC), refer to paragraph (7) below. When the basic receiver is in use, you may select IS video, PROC video, sector MTI video, or 360° MTI video for display on the PPI's. For a discussion of these video displays, refer to paragraphs (3) through (5) below. You may select this mode of operation when

multiple strobes are being passed by the main and strobe receivers and they are saturated. However, this is considered an emergency mode of operation.

- (3) *I.S. switch-indicator.* When the I.S. switch indicator on the LOPAR control-indicator is illuminated (green), IS video will be displayed on the PPI's. You may select IS video when either the AJD or basic receiver is in operation. For a discussion of the IS mode of operation, refer to paragraph 14f.
- (4) *PROC switch-indicator.* When the PROC switch-indicator on the LOPAR control-indicator is illuminated (green), PROC video is displayed on the PPI's. You may select PROC video when either the AJD or basic receiver is selected. For a discussion of the PROC mode of operation, refer to paragraph 14.1b(3).
- (5) *360° MTI and SECTOR MTI switch-indicators.* The 360° MTI or SECTOR MTI switch-indicator may be used only when the basic receiver is selected. When the 360° MTI switch-indicator is illuminated (green), it indicates a 360° MTI effect on the PPI presentation. When the SECTOR MTI switch-indicator is illuminated (green), it indicates that the MTI effect is present over a sector of the PPI presentation. This sector is established by the setting of the MTI SECTOR ANGLE knob on the LOPAR auxiliary control-indicator. For a discussion of the MTI effect, refer to paragraph 14c.
- (6) *FREQUENCY DECREASE and FREQUENCY INCREASE switch-indicators.* These switch-indicators located on the LOPAR control-indicator may be used to either vary the frequency of the tunable magnetron to evade narrow-band jamming frequencies or to look for holes in the spectrum of wide-band jamming.
- (7) *GAIN—AGC knob maximum clockwise (in AGC).* When the AGC in-

dicator light is illuminated (green), the basic receiver can be used as a fixed gain receiver, using only the FAGC feature of the AJD receiver. Figure 11.8 is a simplified block diagram of the effects of rotating to the maximum clockwise position, the GAIN—AGC knob, which is functionally the same as the RECEIVER GAIN knob. In this position a fixed bias is applied to the main IF pre-amplifiers, which establishes maximum gain to the main IF signals. At the same time, a relay ground is applied to the fast AGC amplifier, which applies the FAGC voltage to the main acquisition IF amplifier. For the effects of this FAGC voltage, refer to the discussion in paragraph 14.1a(2) (b). The output video, with FAGC action, is applied to the video distribution circuits for distribution to the presentation system. Figure 11.9 shows the effects of rotating, to the maximum clockwise position, the GAIN—AGC knob, which is functionally the same as the RECEIVER GAIN knob.

b. *LOPAR Nonselective ECCM Devices and Capabilities.* For a discussion of the LOPAR ECCM devices and capabilities, refer to paragraph 14.1a(2) (a) through (d).

15.7 (CMHA). EFS/ATBM HIPAR ECCM Devices and Capabilities of the ATBM System

The EFS/ATBM HIPAR provides you with a simultaneous display of the outputs of two separate receivers which contain many ECCM features. These receivers are generally referred to as AJD RECEIVER (main, with MTI and strobe) and JS ONLY RECEIVER (strobe). Figure 11.10 is a simplified block diagram of the HIPAR with AJD, which is functionally identical to the EFS/ATBM HIPAR. The video you see on the indicators is a composite video consisting of a combination of coherent (coho) video, integrated video, strobe video, and/or noncoherent (noncoho) video. For a discussion of the scope patterns, refer

to a (2) through (6) below. The purpose of the main receiver, also referred to as target receiver, is to reject jamming signals and to provide you with only target information on the PPI's. The MTI, including both coho and noncoho channels, cancels ground and random clutter (chaff, rope, corner reflectors, clouds, etc.), rejects jamming signals, and provides target information to the indicators. Although the main receiver (with MTI) provides target information and rejects received jamming signals, it cannot portray targets which are being masked by jammers. Therefore, a second receiver is necessary to disclose the position of existing jammers. This is accomplished by the strobe receiver, which provides you with an azimuth strobe line on the indicators coincident with the azimuth of each jammer. The output of the strobe receiver is superimposed, at a reduced intensity level, upon the main receiver portion of the acquisition presentation. This composite presentation of main and strobe receivers provides you with a display which portrays target information, cancelled ground and random clutter, and indication of jammer azimuth. This is accomplished automatically with a minimum of switching, thus allowing you to operate at maximum efficiency. You should be free to devote your full time to the detection, evaluation, and designation of the enemy targets in an ECM environment. There are some ECCM controls and features of the EFS/ATBM HIPAR, other than the built-in features, which have a particular significance in ECCM operation. These selective and nonselective devices and features are discussed in *a* and *b* below.

a. EFS/ATBM HIPAR Selective ECCM Devices and Capabilities.

- (1) *PPI indicators.* For a discussion of the PPI indicators used with the ATBM system, refer to paragraph 15.6a(1).
- (2) *EFS/ATBM HIPAR receiver selection.*
 - (a) *AJD RECEIVER switch-indicator.* When AJD RECEIVER switch-indicator on the HIPAR control-indicator is illuminated (green), all of the nonselective AJD features of the EFS/ATBM HIPAR are utilized

and the selective features may be used, singly or in combination, to allow you to operate at maximum efficiency.

- (b) *JS ONLY RECEIVER switch-indicator.* When the JS ONLY RECEIVER switch-indicator on the HIPAR control-indicator is depressed, the outputs of the main receiver are removed, and only the output of the strobe receiver will be presented on the indicators. In a transmission ECM environment which causes multiple strobes, through the main receiver, you may be required to use this position. Figure 11.15 shows the effects of depressing the JS ONLY RECEIVER switch-indicator, which is functionally the same as placing the DISPLAY switch to STROBE ONLY in INH HIPAR systems. You will see a strobe from each jammer, reflected returns from ground clutter, and large targets beyond the strobe range gate setting.
- (c) *BASIC RECEIVER switch-indicator.* When the BASIC RECEIVER switch-indicator on the HIPAR control-indicator is illuminated (green), all of the AJD features of the EFS/ATBM HIPAR are removed, and you are provided with the capability of manually controlling the HIPAR receiver gain by rotating the HIPAR RECEIVER GAIN knob. Decreasing the receiver gain reduces received transmission jamming and presents only a narrow jamming strobe on the indicator. You should notice as you decrease the gain of the receiver that all presentation on the indicator is reduced. Figure 11.11 shows these effects. This feature should only be used during an engagement as an emergency means when saturation occurs in the AJD receiver.

Note. Key numbers shown in parentheses in (3) below refer to figure 11.12.

- (3) *CLUTTER GATE ON switch-indicator.* When the CLUTTER GATE ON switch-indicator on the HIPAR control-indicator is illuminated (green), the clutter gate circuits are operating. Figure 11.12 shows the normal presentation pattern using clutter gating. The areas of presentation from the center of the scope are coho MTI video (6), integrated video (3), and noncoho MTI video (5). The length of the strobe video (1) is controlled by the adjustment of the strobe range gate (2). The area of coverage of the coho MTI is controlled by the adjustment of the MTI range gate (7). Any random clutter (4) would be greatly reduced by the clutter gating action. The presentation you see on the scope as the result of clutter gating is shown as noncoho MTI video (5). Therefore, the EFS/ATBM HIPAR system will present to you a composite video presentation on the scope.
- (4) *CLUTTER GATE ALL RANGE switch-indicator.* When the CLUTTER GATE ALL RANGE switch-indicator on the HIPAR control-indicator is illuminated (green), the coho MTI video is replaced by integrated normal video or clutter gated noncoho MTI video. You can use this position to remove the effects of chaff in the coho MTI area. Figure 11.13 shows the effects of removing the clutter presentation from the coho area by using the CLUTTER GATE ALL RANGE switch-indicator in the EFS/ATBM HIPAR systems, which is functionally the same as using the ALL RANGE position of the CLUTTER GATE in INH HIPAR systems.
- (5) *CLUTTER GATE OFF switch-indicator.* When the CLUTTER GATE switch indicator on the HIPAR control-indicator is illuminated (green), the clutter gating is removed, and the main receiver fast automatic gain control (FAGC) is energized. This method of operation is very effective

against a jamming frequency within the wide bandpass but not in the narrow bandpass of the receiver. The effects of this jamming would cause quieting (cw capture) of the targets and clutter in the normal receiver area. Figure 11.14 shows the effects of this capture and the results of using the CLUTTER GATE OFF switch-indicator in the EFS/ATBM HIPAR systems, which is functionally the same as setting the CLUTTER GATE switch to OFF in INH HIPAR systems.

- (6) *STAGGER OFF switch-indicator.* During normal operation, the stagger prf is used. The stagger circuits are used to vary the time intervals between transmitted pulses. This type of transmission eliminates an undesirable MTI problem and aids in preventing an enemy jammer from locking on your prf. The video presentation you will see will be main, with MTI, and strobe video. When the STAGGER OFF switch-indicator is depressed, the stagger prf is removed, and the transmitting system assumes a constant prf mode of operation. In a transmission ECM environment used to confuse or deceive you, such as spoofers, the use of the constant prf mode of operation will enable you to identify the targets from the spoofers. Figure 11.16 shows spoofers on the indicator and the effects of depressing the STAGGER OFF switch-indicator, which is functionally the same as setting the DISPLAY switch to STAGGER OFF in INH HIPAR systems. In the stagger prf mode, each spoofer will be presented as a pair slightly separated in range. A target will always present only one return in the stagger prf mode or in the constant prf mode. Depressing the STAGGER OFF switch-indicator will present only one spoofer, not a pair. By alternately switching between STAGGER OFF and normal, you can determine which of these returns are targets.

- (7) *CHANNEL SELECT switch-indicators.* Ten CHANNEL SELECT switch-indicators on the HIPAR auxiliary control-indicator provide you with the capability of selecting any one of 10 preset frequencies. These switch-indicators may be used to evade the narrow band jamming frequencies or to look for holes in the spectrum of wide-band jamming. The EFS/ATBM HIPAR system allows frequency switching with no interruption in presentation.

b. EFS/ATBM HIPAR Nonselective ECCM Devices and Capabilities.

- (1) *Dicke-fix, FAGC, FTC, and stagger prf capabilities.* For a discussion of the Dicke-fix, FAGC, FTC, and stagger prf features, refer to paragraph 15.2b (1) through (4), respectively.
- (2) *Video integration, strobe line, and MTI capabilities.* For a discussion of the video integration, strobe line, and MTI capabilities, refer to paragraph 15.2b (5) through (7).
- (3) *Clutter gate capability.* The clutter gate receives integrated video signals from the main receiver, and coho and noncoho MTI video from the MTI. To eliminate close-in clutter, coho MTI video is passed, unchanged, to the presentation circuit. This unchanged coho MTI presentation is limited to

the preadjusted MTI range gate area. For noncoho MTI signals to be applied to the PPI's, the integrated signals from the main receiver must be of a duration longer than 9 microseconds. When a video signal is longer than 9 microseconds in duration, the noncoho MTI output of the clutter gate circuits will replace the integrated video from the main receiver during these periods. Figure 11.21 is a simplified block diagram of the clutter gate action. For the PPI presentation patterns, refer to figure 11.12. The clutter gating effects are controlled by the switch-indicators described in a(3) through (5).

15.8 (CMHA). General Operating Principles of the NIKE-HERCULES ATBM System

The following principles, though not restricted to ECCM operation, are of particular importance when you are operating in an ECM environment.

a. During an ECM environment it is important that you engage your target at the earliest opportunity. The maximum range presentation on both scopes should be used.

b. When an ECM environment is first detected, the short persistency display should be selected to eliminate the possibility of targets being masked by the persistency of the PPI's.

c. You may use the ERASE switch-indicator to eliminate intermittent multiple strobing.

**Section II (CMHA). TRACKING RADARS (NIKE-AJAX AND
NIKE-HERCULES RADAR SYSTEMS)****16 (CMHA). General**

The information in this section is directed primarily to the target tracking radar operators (the target tracking radar is a much more active member of the ECCM team) rather than the missile tracking radar operator. The mis-

sile tracking radar warrants very little discussion in connection with ECM because it is very difficult for the enemy to effectively jam it. If the enemy does succeed in jamming the missile tracking radar, there is no way to counteract the jamming. The only action required is to observe the effects on the missile

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track radar indicator and report them to your superior.

17. (U) ECM Environment

All electronic countermeasures used against the target radar will be designed to do one or more of three things: deceive, confuse, or obscure.

a. Deception. Deception techniques you can expect to be used against the target tracking radar include spot chaff, corner reflectors, spoofers, decoys, range gate stealing, angle tracking deception, and blinking.

b. Confusion. Confusion techniques you can expect to be used against the target tracking radar include chaff, corner reflectors, spoofing, and some forms of modulated cw.

c. Obscuration. Obscuration techniques you can expect to be used against the target tracking radar include chaff, unmodulated cw, modulated cw, and direct noise.

18. (U) ECM Analysis and Reporting

When you are aware that electronic countermeasures are being used against you, immediately determine the type and the effectiveness of ECM. Report this information to your superior as quickly and accurately as possible without delaying your ECCM action. The specific procedures to be used in reporting ECM will be set forth in the applicable standard operating procedure for your command.

a. Type of ECM. Detailed information which will aid you in identifying the type of ECM is presented in chapter 3.

b. Effectiveness of ECM. The effectiveness can be reported as ineffective, partially effective, or totally effective, depending on your ability to see the target and maintain a smooth track in the presence of the jamming. The degrees of effectiveness are defined as follows:

- (1) *Ineffective.* Jamming is evident on your indicators but does not affect your tracking operation.
- (2) *Partially effective.* Jamming causes intermittent loss of the target return or causes you to be uncertain as to which is the real target if false targets are present.
- (3) *Totally effective.* Jamming causes you to lose track completely.

19. (CMHA) ECCM Devices and Capabilities

Described below are the controls and features of the target tracking radar which have significance in ECCM operation.

a. Plan Position Indicator (PPI) and Precision Indicator (PI). The focus, intensity, and video gain controls for the PPI and PI should be adjusted according to normal adjustment procedures for optimum presentation on the indicators and these controls should not be used in ECCM operation. These indicators can be very useful aids in operating against certain types of ECM. You can use the jamming-signal main strobe on the PPI as an early indication of target azimuth when the acquisition radar is being jammed. Using the PI, you can employ aided range tracking to track the target if the range tracking indicator is rendered useless by jamming and if the acquisition radar is not being jammed at the same time.

b. FREQUENCY INCREASE-DECREASE Switch. This switch may be used to vary the frequency of the tunable magnetron to evade the jamming frequency or to look for holes in the spectrum of wide band jamming. This switch may be used in conjunction with the INTERRUPT RF-INTERRUPT RF switch.

c. INTERRUPT RF-INTERRUPT RF Switch.

- (1) This switch can be used with the

TM 9-1430-250-10/3

FREQUENCY INCREASE-DECREASE switch to evade the jamming frequency. The combined use of these two switches is effective primarily against jammers which are designed to track any frequency change you make. When the INTERRUPT RF-INTERRUPT RF switch is operated to either side, the transmitted energy of the radar is directed into a dummy load. When the two switches are operated simultaneously, a frequency tracking jammer will lose track for at least a short time since it receives no energy from the radar while you are changing frequency. When the INTERRUPT RF-INTERRUPT RF switch is in use, the radar automatically switches to the aided rate mode of operation regardless of the position of the MAN-AID-AUTO switches. This switch may be used frequently as necessary but should not be held for more than four seconds at one time. It may be difficult for you to know whether to change frequency only or to interrupt transmission while you change frequency. The presence of jamming does not reveal whether the jammer is designed to track changes in frequency, or whether the jamming covers a wide or narrow frequency band.

- (2) Outlined in figure 12 is a procedure which will help you to make optimum use of the combination of these two switches to combat the jamming and at the same time determine certain characteristics of the jamming. The word "dump" will be used to indicate the use of the INTERRUPT RF-INTERRUPT RF switch; the word

"tune" will be used to indicate the use of the FREQUENCY INCREASE-DECREASE switch. This procedure will be referred to as "dump and tune" in the instructions of chapter 3. As shown in figure 12, when jamming appears, dump and tune simultaneously. If the jamming indications do not disappear at least momentarily, you can assume that the jamming covers a wide band, such as direct noise, or is being swept at a very fast rate. You should then tune for holes in the jamming or attempt to tune away from the jamming in the event that it does not cover your entire frequency band. If the jamming disappears when you dump and tune, you can assume it is narrow band jamming. If it does not reappear, you have succeeded in the evasion. If it does reappear, you can assume that the jammer is tracking your frequency change. You should then continue to dump and tune each time the jamming reappears.

d. MAN-AID-AUTO Switches. A MAN-AID-AUTO switch is provided for each operator. These three switches should be set to the AID position when operating in an ECM environment. By setting these switches to the AID position, you will possibly offset the effects of many ECM techniques, including the more sophisticated ones such as range gate stealing, angle track deception, and blinking.

e. VIDEO AMP Switch. This switch controls a video amplifier in the radar receiver circuitry to provide amplification of the video appearing on the three tracking indicators. The two on positions provide amplification factors of five and ten (NIKE-AJAX) or three and six (NIKE-HERCULES). When you are operating against transmission jamming signals which

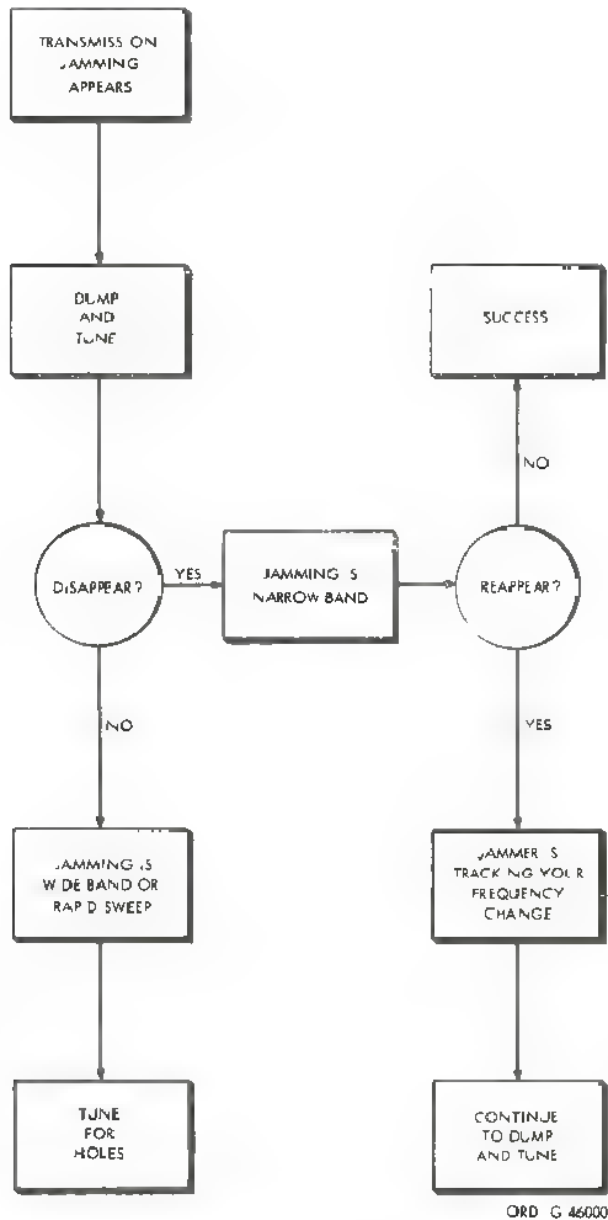


Figure 12. (CMHA). Jamming frequency evasion procedure.

tend to obscure the target return, this added amplification may aid you by accentuating the target video or the break in the baseline. The break in the baseline is caused by target video and indicates target range. The added amplification is particularly helpful against unmodulated cw jamming. The unmodulated cw jamming signal tends to affect the receiver automatic gain control so that the target return signal is not amplified enough to present a usable pulse on the indicators. The target video may become visible when you operate the VIDEO AMP switch to provide additional video amplification.

f. IMAGE SPACING Switches. An IMAGE SPACING switch is provided for each operator. On the azimuth and elevation indicators, this switch may be set to OFF or NORMAL for normal operation. On the range indicator, this switch should be set to NORMAL position for normal operation. If it is set to OFF, the baseline of the tracking indicator presentation may begin to jitter. The SEL SIG position of all three switches causes all but the 500-yard expanded portions of the sweeps on the respective indicators to be blanked out. The use of the selected signal will rid the indicators of much of the distracting and confusing clutter caused by jamming, and may provide the best presentation on the elevation and azimuth indicators. The range operator should not use the SEL-SIG position due to the limited range display.

g. Track-On-Jamming Capability. This radar is capable of angle tracking jamming signals in both azimuth and elevation. This can be accomplished in either automatic or aided tracking modes. With angle data obtained in this manner, and range data from the PI (providing acquisitional range data is available), you will

be able to destroy the aircraft in the presence

of high intensity jamming. This idea applies only if the jammer is the desired target.

h. SWEEP LENGTH Control. The SWEEP LENGTH control at each tracking indicator may be used to expand the inner portion of the range sweep while you are tracking a target through jamming. It has been shown that the actual width of the target pulse on the indicator affects the visibility of the target to an operator. In general, the wider the pulse, the more readily visible it will be, although there is a desirable limit to the width of the target pulse. Therefore, if you periodically adjust the SWEEP LENGTH control to maintain the expanded portion of the range sweep near the right edge of the indicator while tracking, you will maintain maximum target pulse width consistent with range and the target will be more easily detectable.

The use of this control must be restricted to the time during which you are tracking a particular target. This control must be set for maximum sweep length during target designation and acquisition.

20 (U). General Operating Principles

In an ECM environment, the normal tracking mode in azimuth, elevation, and range is aided tracking. In many cases you will be placed at an unnecessary disadvantage by tracking in automatic and being suddenly subjected to jamming. You should use aided tracking throughout an enemy encounter. If jamming is not evident when first setting up a track, you may switch momentarily to automatic in order to set up the initial tracking rates; then revert to aided tracking.

Section II.1 (CMHA). TRACKING RADARS (IMPROVED NIKE-HERCULES RADAR SYSTEMS)

20.1 (CMHA). General

The information in this section is directed to the target tracking radar (TTR) operators of the Improved NIKE-HERCULES (INH) radar system. For the discussion of the missile tracking radar (MTR) and MTR operator's duties in connection with ECM, refer to paragraph 16. This section describes the ECCM devices and capabilities of the TTR and target ranging radar (TRR) systems and provides general operating principles in an ECM environment. The TRR used in conjunction with the TTR provides you with a tracking radar system capable of combatting severe ECM tactics. This radar combination contains three separate receiver-transmitter systems. The TTR system is capable of angle tracking a target in azimuth and elevation in a transmission jamming environment while the TRR, with its two receiver-transmitter systems, is very effective in providing range information when the TTR is being jammed. The simultaneous presentation of TTR and TRR range information on the target range indicator, and the panoramic display of the TRR frequency spectrum on the countermeasures control indicator enables you to select that radar and radiating frequency which will produce the best range tracking mode of operation. Your ability to utilize range information from two radars, to make instan-

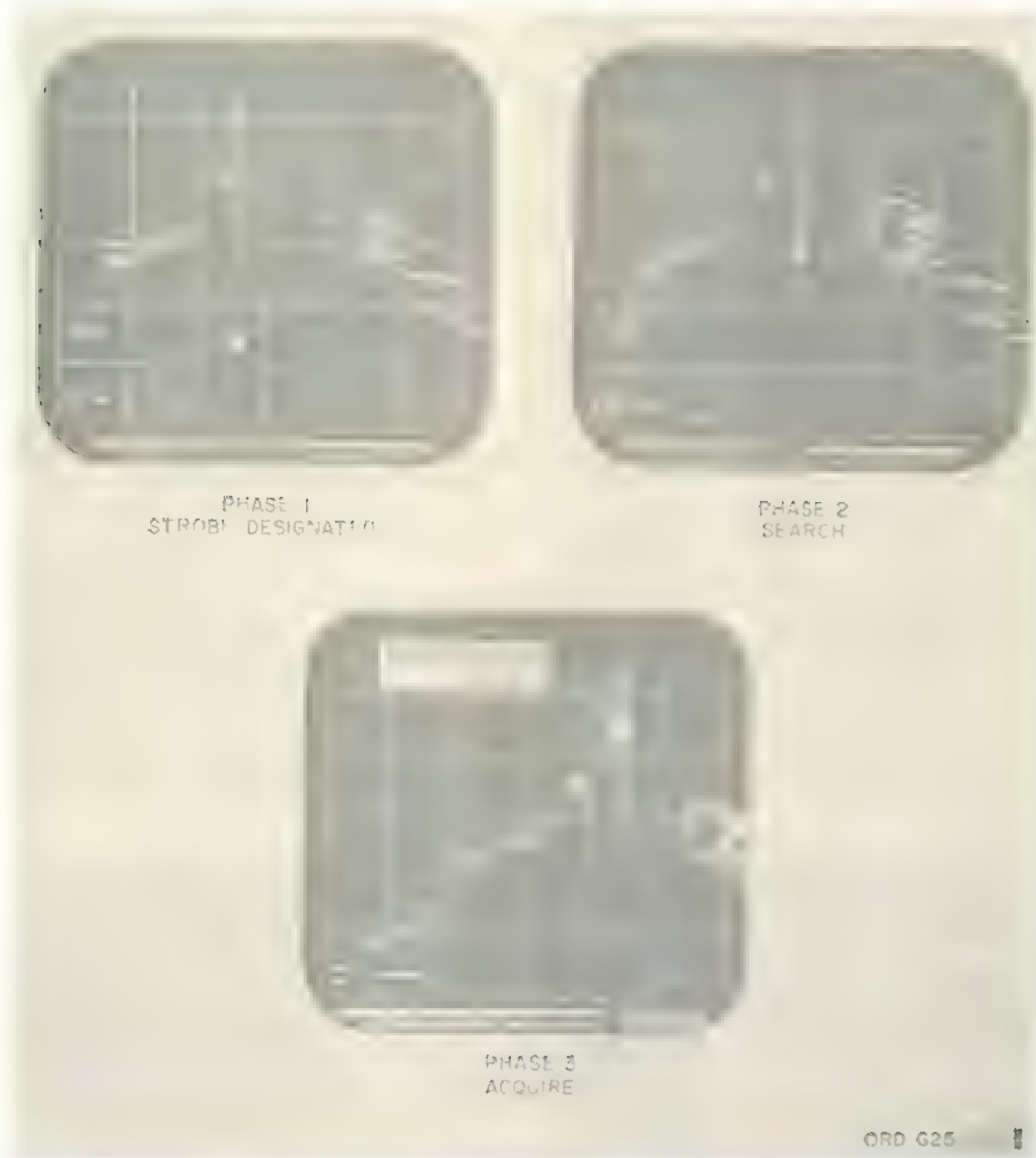
taneous transmitter frequency changes, and to switch the transmitted pulse width will enable you to complete your mission in a severe ECM environment. For a discussion of ECM environment and ECM analysis and reporting, refer to paragraphs 17 and 18, respectively.

20.2 (CMHA). ECCM Devices and Capabilities

Described below are the controls and features of the TTR and TRR system which have significance in ECCM operation.

a. Indicators.

- (1) *B scope indicator.* The B scope indicator displays an expanded portion of the PPI presentation, 220,000 yards in range and 60 degrees in azimuth. When the acquisition radar operator designates a strobe, this strobe will appear centered in the displayed sector on the B scope indicator when you operate the ACQUIRE switch. You can use this strobe line as an indication of target azimuth. By maintaining the track circle on the strobe line, you can search for the jamming target in elevation and range. This operation is illustrated in figure 12.1. If necessary, you could also utilize the B scope to range track a target if the



■ *Figure 12.1 (CHMA). Strobe technique of target transfer and acquire. (U)*

target range indicator is degraded by jamming, but the acquisition radar is painting the target. This would be done by maintaining the track circle over the target in the aided tracking mode of operation

- (2) *Countermeasures control-indicator.* The countermeasures control-indicator provides you with a complete picture of the TRR frequency spectrum and range information. This display permits you to monitor the tuned frequencies of the two transmitters relative to any jamming frequencies in the Ku-band. When experiencing wide-band or fast swept-frequency jamming, you can observe the panoramic sweep on the indicator and tune the nonradiating transmitter to the frequency of minimum interference. Then you can switch transmitters and radiate at that frequency which provides the best range information as indicated on the lower trace of the indicator. The countermeasures control-indicator is also a very effective aid in combatting on-frequency jamming. This operation is illustrated in figure 12.2. If a lock-on type jammer is being used against your tracking radar, the jamming sig-

nal will produce an additional pair of pips on the pedestal with the paired pips generated by the radiating transmitter. See figure 12.3. By continually switching transmitters and retuning, you should be able to effectively evade this type jamming.

- (3) *A scope indicators.*

- (a) The azimuth, elevation, and target range indicators provide either A or R type presentation. When you select A type presentation, maximum 200,000-yard range information is displayed on the upper trace of the azimuth and elevation indicators and on both traces of the range indicator. As you vary the range handwheel, the range notch moves along the baseline proportional to the change in range. When you select R type presentation, a 40,000-yard segment of the total 200,000-yard range information is displayed on the indicators. In this type presentation, the notch remains stationary in the center of the scopes with 20,000 yards of the range sweep displayed on either side. The range dials on the target range indicator indicate the relative position



JAMMING FREQUENCY



AFTER TUNING

ORD G258011

Figure 12.2 (CHMA). Effects of frequency change during on-frequency spot jamming. (U)



Figure 12.3 (CMHA). Effects of PAN switch indicated on countermeasures control indicator. (U)

of the notch on the full range sweep. When acquiring a target in an ECM environment, the A presentation is preferable since maximum range is displayed on the A scopes. After the target is initially acquired, you may then select R type presentation. The significant ECCM function of the R type presentation is that it provides an expanded display of the range information in the vicinity of the target pulse. This allows you to more readily distinguish between the target video and any ECM jamming signals.

- (b) The target range indicator displays the TTR range information on the upper trace and the TRR range information on the lower trace. This permits you to observe the presentation from both radars simultaneously.

b. *Frequency Tuning.* The TTR and TRR system provides continuous tuning capability across the X-band (TTR) and Ku-band (TRR). For a discussion of TTR tuning operations to be performed in an ECM environment refer to

paragraph 19b and c. The TRR contains two separate transmitters which operate simultaneously. While the output of one transmitter is being radiated into space, the output of the other is applied into a dummy load. The non-radiating transmitter may be tuned to any frequency between 15,500 and 17,500 megacycles. You can switch from one to the other with no interruption of transmitter operation. This feature enables you to change the operating frequency up to 2000 megacycles instantaneously if the transmitters are tuned to opposite ends of the operating frequency band. This capability, used in conjunction with the panoramic display on the countermeasures control-indicator, is very effective for locating "holes" in wide-band jamming and evading on-frequency jamming.

c. *Transmission Interrupt.* Both the TTR and TRR have provisions for momentary interruption of transmission. This capability of the TTR is discussed in paragraph 19c. Either of the PAN switches, one on the remote transmitter control and another on the countermeasures control-indicator, can be used to interrupt the radiating TRR transmitter. When either of these switches is set to the NO LOSS position,

the outputs of both transmitters are directed into dummy loads (the two main receivers are disconnected from the antenna) and the panoramic receiver is coupled directly to the antenna. This eliminates all reflected video and removes the input signal attenuator used in normal operation. In this condition, the panoramic receiver provides maximum gain of all received ECM transmission within the frequency band of the TRR and displays this information on the panoramic upper trace of the countermeasures control-indicator. In the NO LOSS mode, you will observe on the scope that all target video disappears and all received ECM transmission increases in amplitude. When you return to the NORM mode, the target video reappears and the amplitude of the jamming signals decreases. By alternately switching between NORM and NO LOSS and observing the results on the panoramic scope, you can readily distinguish between target video and transmitted ECM. See figure 12.3.

d. Pulse Width Switching. The TTR and TRR system is capable of transmitting long pulses of 2.5 microseconds duration and short pulses of 0.25 microsecond duration. In the long pulse mode of operation, the range notch appearing on the scope trace is 1000 yards wide. In the short pulse mode of operation, the range notch is 100 yards wide. You should normally use the long pulse mode when tracking targets at long range or during an ECM engagement because the transmitted pulse is of increased average power which provides a stronger target return. However, you may select the short pulse mode for the TRR when you are experiencing chaff clutter or when you suspect multiple targets. Figure 12.4 illustrates the effects of switching to short pulse on chaff and figure 12.5 shows the effects on multiple targets.

e. Tracking Modes. The MAN-AID-AUTO switches for azimuth and elevation tracking are discussed in paragraph 19d. The MAN-ACQUIRE AID-TRACK AID-AUTO switch is provided for selection of range tracking modes of operation. When operating in an ECM environment, this switch should be set to one of the AID positions. If a strobe is designated and you are using the B scope as described in a

above to acquire the target, you should set the switch to the ACQUIRE AID position. You should use the TRACK AID position when you are tracking a target on the target range indicator. These aided modes of operation permit you to make necessary adjustments in the tracking rate and prevent the radar from "locking on" to strong jamming signals.

f. SWEEP LENGTH Control. When A type presentation is selected, the SWEEP LENGTH control functions as described in paragraph 19h. This control, however, has no effect on R type presentation.

g. Track-On Jamming Capability. Refer to paragraph 19g.

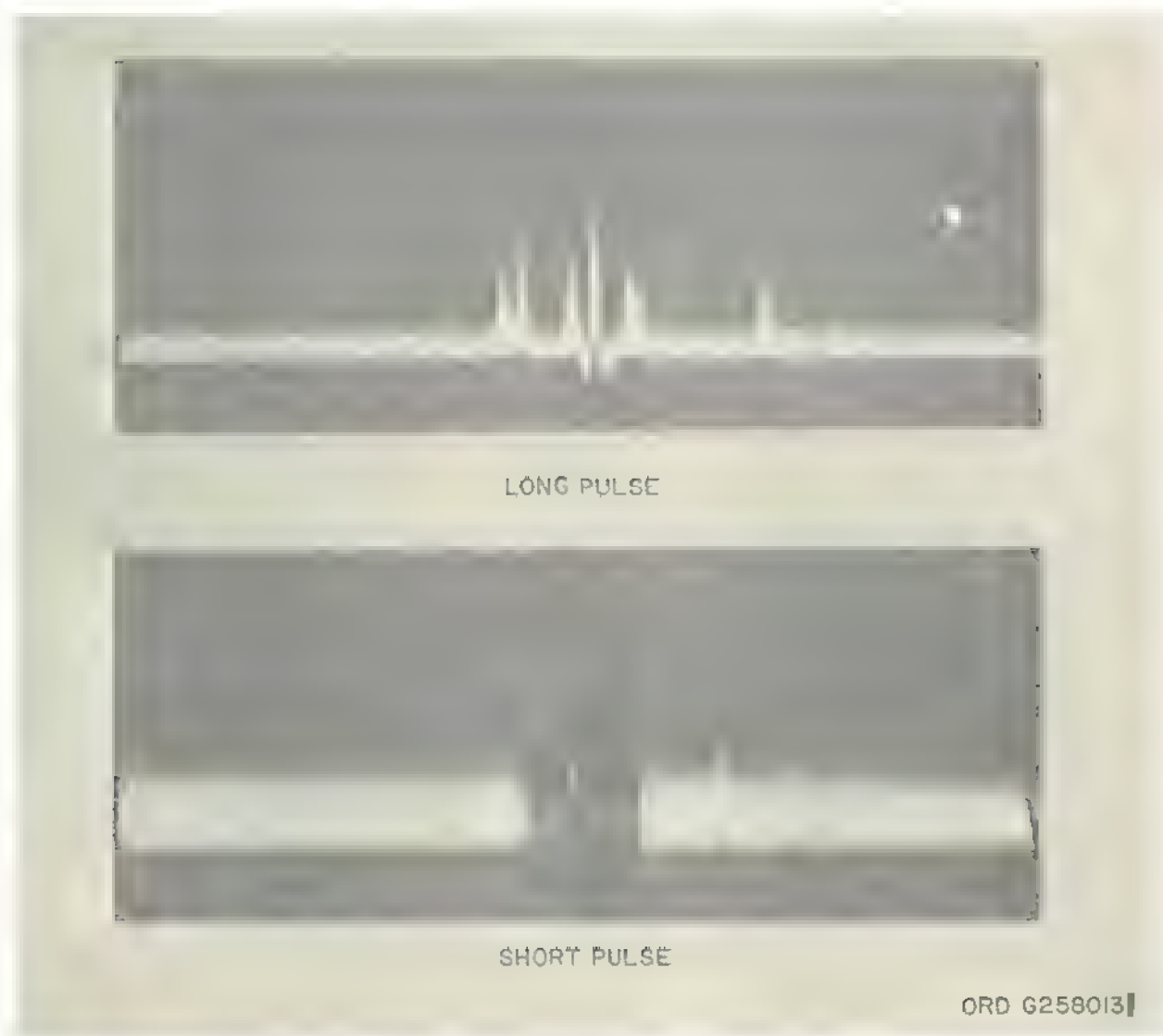
20.3 (CMHA). General Operating Principles

The primary function of the target tracking radar system operators is to acquire the designated target with minimum delay and track it as accurately as possible until the kill occurs. Described below are some general operating principles which should aid you in completing your mission in an ECM environment.

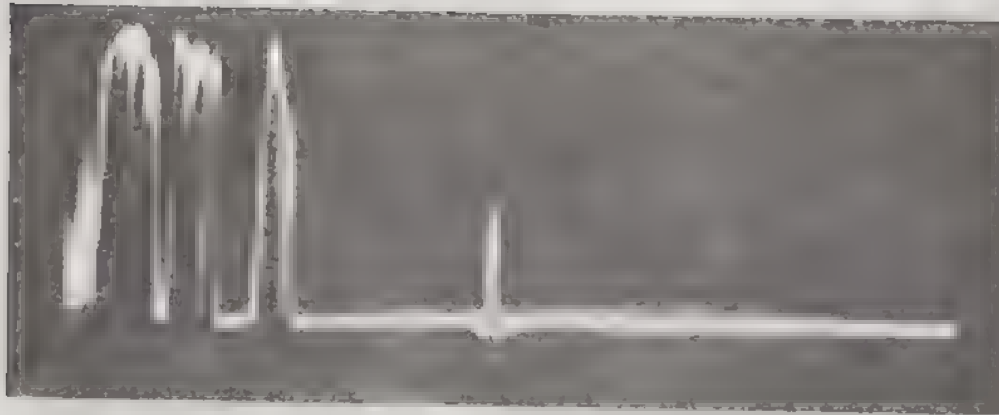
a. You should use the long pulse mode of operation for initial acquisition and tracking at long ranges because it provides greater power and range capability. The short pulse mode should be used only at short ranges, as an aid in tracking targets through chaff, or for identification of multiple targets.

b. When acquiring a target in an ECM environment, you should select A type presentation for initial acquisition of the target. This type presentation allows you to observe all received signals within the full 200,000-yard range of your radar. After you acquire the target, you should then switch to R type presentation which provides better target definition.

c. In an ECM environment, the normal tracking mode in range is aided tracking. In many cases, you will be placed at an unnecessary disadvantage by tracking in automatic and being suddenly subjected to jamming. You should use aided tracking throughout an enemy encounter. If jamming is not evident when first setting up a track, you may switch momentarily to automatic in order to set up the initial tracking rates; then revert to aided tracking.



■ *Figure 12-4 (CMHA) Effects of pulse width switching on chaff (U)*



LONG PULSE



SHORT PULSE

ORD G258014

■ *Figure 12.5 (CMHA). Effects of pulse width switching on multiple targets. (U)*

CHAPTER 3 (CMHA)

COMBATting ENEMY ELECTRONIC COUNTERMEASURES

Section I (CMHA). ACQUISITION RADARS (NIKE-AJAX AND NIKE-HERCULES SYSTEMS)

21. (CMHA) Deception Techniques

In this paragraph, we will discuss techniques the enemy may use in an attempt to present false information to the acquisition radar in such a way that you do not recognize it as false information. What you can do to offset the deceptive quality and operate against these techniques is also discussed. The most important and most difficult part of combatting deception techniques is being able to recognize the deception. The general nature of these techniques are such that once you see through the deception, the false indications become just so much clutter on your indicators and are rather easy to work through. In order that a false indication be truly deceptive, it must resemble very closely a true aircraft indication. Therefore, you cannot rely on the appearance of an indication to determine that it is a false return. The two primary characteristics of a deceptive false return which may enable you to recognize it as false are its motion and its changing appearance. These are two things for which you must watch. Therefore, in the case of deception ECM, we cannot illustrate the effects which the ECM have on your indicators since at a given time the indicators will present a seemingly normal indication. We can only discuss the characteristics of the various techniques which, if you see them, will reveal to you that the enemy is employing ECM.

a. Spot Chaff, Corner Reflectors, and Rope. The deceptive quality of all these devices is rather short-lived and can be eliminated if you

are alert. If any or all of these devices are used in a limited number, it is possible that you will mistake them for real aircraft on your indicator. The returns from these devices will appear suddenly, as if aircraft had maintained themselves invisible to the radar until within a certain range. If you detect this sudden appearance of additional targets in the vicinity of an already visible target, you will suspect that these indications are not real aircraft. You cannot be certain, however, even if you detect the sudden appearance of a target at a relatively short range. The indication may be that of a real aircraft employing the pop-up tactic. Observe carefully the size and motion of the new targets. If they travel much slower than the aircraft, they are reflecting devices. Chaff can be identified further by the increasing size of the return as the chaff disperses. This motion factor indicates that your most effective ECCM technique is the use of the MTI to reduce the false returns on the indicator. If the enemy's intent is deception, he will make limited use of the devices to simulate a realistic number of aircraft, and the false returns would probably not hinder your operation.

b. Decoys. Decoys are very difficult to distinguish from real aircraft on your indicators. The best way to identify a target as a decoy is to observe the launching of the decoy on your indicators. As an aircraft launches a decoy, the decoy return will seem to grow out of the aircraft return. Even if you do detect the launching, you cannot be certain which return is that of the decoy. This is because the aircraft may

merely drop a decoy which will lag behind the aircraft at a somewhat slower speed; or the decoy may be self-propelled and designed to fly faster than the aircraft. Aided range rate tracking of the target prior to launch of the decoy may provide a possible means of determining the true target return.

c. Spoofers.

- (1) By considering the case of one aircraft employing the spoofing techniques, you can readily apply the discussion to a multiple-aircraft situation. An aircraft employing the spoofing technique is using radar's transmitted pulse to trigger the transmission of one or more pulses which will appear on your indicators as additional targets. These false targets may be offset in range and/or azimuth from the real aircraft target. Therefore it is impossible to establish a set rule for identifying the target only from its position in relation to the spoofers. The enemy's intent is that you will believe that all these targets on your indicators are aircraft and that the target you choose to engage is not the actual aircraft.
- (2) In most cases spoofer returns transmitted by an approaching aircraft will be at a greater range than the aircraft. Although much more difficult, it is possible for an aircraft to cause spoofers to appear at a range shorter than the range of the aircraft. If you detect the sudden appearance of additional targets relatively close to the target you are tracking, you can suspect that they are spoofer returns or returns from reflecting devices. Your only problem is maintaining the track on the original real aircraft return.

You can assume that, if the enemy employs the spoofing technique, he will initiate the action at a long range, probably beyond the maximum detectable range of the radar. The spoofer returns will then appear on your indicators along with or before the real aircraft.

- (3) As the targets decrease range, you may detect characteristics which indicate that not all of the targets are real aircraft. The spoofer returns may not completely resemble the aircraft return. If you see several targets on your indicators and one of the targets possesses some characteristic which the others do not, you can suspect that the others are spoofer returns. For example, several spoofer returns will usually be the same size, but all may be slightly smaller or larger than the aircraft.
- (4) Another means of identifying spoofer returns is by observation of the change in size of the targets as they decrease range. The rf energy of the spoofer return travels through space only half the distance that the radar signal travels. Remember that the spoofer return signal is transmitted from the aircraft to the radar; whereas the target return signal originates at the radar and travels to the aircraft and back to the radar. If the spoofer signal is transmitted by the enemy at a constant power level, the difference in distance traveled by the two signals will cause the power ratio of the two signals at the radar receiver, and as seen on the indicators, to change as range decreases. Of course, the enemy may be able to offset this factor by

varying his radiated power to maintain the ratio constant.

- (5) Another identifying characteristic of spoofer returns is a possible range instability. Range instability can result from inadequacies of the jammer. In the case of spoofer returns at ranges shorter than the aircraft, a variation in radar pulse repetition frequency will cause a variation in range.
- (6) As long as the enemy's intent is deception, he will generate only a small number of spoofer returns which will not seriously affect operation once you are able to distinguish the target from the spoofer. If you wish to rid the indicators of these spoofer returns, first try a change in frequency. If this is effective, continue to make frequency changes as often as the spoofer returns reappear.

22. (CMHA) Confusion Techniques

In this paragraph we will discuss techniques the enemy may use to confuse you by distracting your attention away from an important target or by making you uncertain as to which is the real target among many returns. What you can do to operate against these techniques is also discussed. The primary difference between confusion techniques and deception techniques is that confusion techniques leave no doubt that the enemy is employing ECM.

a. Chaff, Corner Reflectors, and Rope. The primary purpose of these devices is to confuse. When used in this capacity, they will be used in great number to cause numerous false targets on your indicator (fig. 13). In this manner, the enemy attempts to prevent you from maintaining a track on the aircraft as it flies through the area infested with reflecting devices. New methods of using these devices are constantly

being developed. You can expect a lead aircraft in a formation to dispense the devices to provide protection for the remainder of the attacking force; or a single aircraft may dispense the devices in various ways to provide self-protection. Even though these devices slow down and begin falling once released from the aircraft, aircraft flying through a dense concentration of these devices, especially chaff, may be difficult to track if it makes changes in its course and speed. In the presence of this form of ECM, you should first use the MTI to reduce the interference. The interference suppressor in addition to the MTI may further help in this situation. If the indicators are still too cluttered for efficient operation, use aided range tracking to help track the target through the interference while remaining alert for changes in target course or speed.

b. Spoofers. Refer to the discussion in paragraphs 21c. When the enemy generates many spoofer targets, the effect becomes confusion rather than deception (fig. 14). It may become obvious that all these returns are not from aircraft, but it may become very difficult to keep track of the aircraft returns among the numerous false returns. To combat this technique, first try changing frequency. If this is not effective, use the MTI and the interference suppressor. Aided range tracking will help in maintaining a track once you are able to identify an aircraft return.

c. Pulse Amplitude Modulated CW. The effects of pulse modulated cw depend on whether the pulses are synchronized or nonsynchronized with the radar pulse repetition frequency. If the pulses are synchronized, they will affect the PPI by causing one or more circles or portions of circles (arcs), similar to the range circle, to appear (fig. 15). If the pulses are non-synchronized, they will cause spiral strobes, called rabbits, to appear on the PPI as shown in figure

TM 9-1430-250-10/3



Figure 13. Spot chaff on PPI.



Figure 14. Spoofers on PPI.

15. The pulses may also be varied in and out of synchronization. This technique will produce circles similar to those shown in figure 15 but thicker and less well defined. The thickness of the lines will depend on the extent the pulses are varied from synchronization. In any case, the indications on the PPI do not resemble targets but are meant to clutter the indicator and distract your attention. If the circles or rabbits become very dense, the target may be intermittently concealed, but it is unlikely that the enemy could generate enough interference by this technique alone to cause you serious trouble in tracking a target. Another variation of this technique, in which the jamming pulse repetition frequency is completely random, is detailed in paragraph 23, obscuration techniques. The MTI may be used to rid the PPI of the circles caused by synchronized jamming. If further action is necessary, use the interference suppressor and try chang-

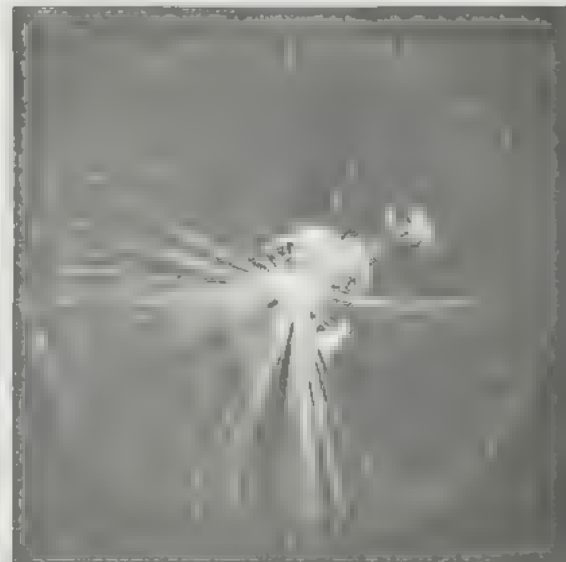
ing frequency. The interference suppressor will be most effective against rabbits and the thicker circles. A name commonly given to the interference suppressor circuits is "rabbit trap." The MTI and changes in frequency may be effective against rabbits and the jagged circles.

d. *Swept Frequency.* Swept frequency jamming is a confusion device; the jamming signals are swept through a large band of frequencies at a slow rate. This technique will affect the PPI in a manner similar to that shown in figure 16. Notice that the jamming strobes are not solid at any one azimuth. From one sweep to the next, the indications appearing at a given azimuth will rarely be at the same point in range. Because of this randomness it would be difficult to obscure a target; therefore the strobing pattern causes confusion. Your best ECCM device is the interference suppressor. A change in frequency may also be effective in the event



ORD G 46014

Figure 15. Synchronized and non-synchronized pulse modulated jamming on PPI.



ORD G 46025

Figure 16. Swept frequency jamming on PPI, slow rate.

that the jammer is not sweeping through the entire frequency band of the radar, although it is relatively easy to cover a very wide frequency band using this technique. The MTI may also be an aid in reducing this interference.

23. (CMHA) Obscuration Techniques

In this paragraph we will discuss techniques the enemy may use to obscure the target returns on your indicators, and what you can do to operate against these techniques. Obscuration techniques are those which are intended to hide the target (reflection techniques) or overpower the target return signals (transmission techniques).

a. Chaff Corridor. Chaff corridor implies the release of a steady stream of chaff by a lead plane in an attacking formation. As the chaff disperses it forms a corridor or cloud

through, or behind, which the formation may fly (fig. 17). If the chaff is employed efficiently by the enemy, you will have much difficulty in seeing the targets. However, you can designate the range and azimuth of the chaff-infested area to the target tracking radar and the target tracking radar operators may be able to acquire a target provided the chaff is less effective against that radar. Watch the boundaries of the chaff corridor for aircraft which may wander out of the concealment. Of course, you should first attempt to rid your indicators of the chaff return. The MTI will probably be most effective against the chaff. The use of the EXPANSION and EXPANDED POSITION controls of the PPI may also help in detecting a target in the chaff cloud. Again, these controls should be used only when a specific target has been selected for engagement.

TM 9-1430-250-10/3



Figure 17. Chaff corridor on PPI.

b. *Unmodulated CW.* Unmodulated cw jamming tends to drive the receiver toward cutoff and blank out the PPI. The effect of this can be seen in figure 18. View A is a normal presentation, view B is with cw jamming present. This type jamming is recognizable more by its effects than by the jamming signal itself. Little or no indication of jamming will be visible on the PPI except that targets, as well as ground clutter, will fade out. In combatting this technique, your first consideration should be the evasion of the jamming frequency. This type jamming will be present only at one or more specific frequencies at a time, depending on the number of jammers. By repeatedly changing your operating frequency you should be able to obtain sufficient target information unless the



Figure 18. Effects of unmodulated cw jamming on PPI.

TM 9-1430-250-10/3



ORD G 4605

Figure 19. Random pulse amplitude modulated jamming on PPI.



ORD G 46016

Figure 20. Square wave amplitude modulated jamming on PPI.

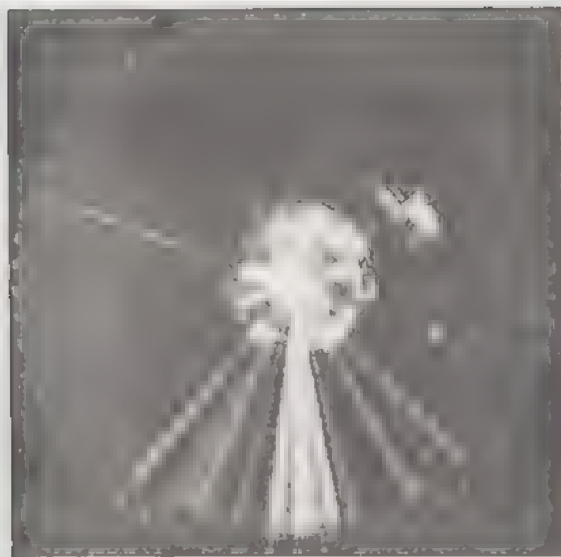
jammer has sufficient frequency tracking capability to track your most radical frequency changes.

c. Modulated CW. A cw signal can be amplitude or frequency modulated with a variety of wave shapes. The effectiveness will vary with different modulating waveshapes and your ECCM action will be essentially the same in each case. Figures 19 through 22 show the effects on the PPI of some of the most common modulated jamming signals. Figure 23 shows the effects on the PPI when the acquisition radar is subjected to several types of jamming signals simultaneously. Your first ECCM action should be an attempt to evade the jamming frequency by making frequency changes. If this action is unsuccessful, use the IS switch and the MTI to possibly reduce the interference on the PPI. If all attempts to see through jamming

fail, use the strobe line technique to designate the target. As range decreases, the target may become visible on the strobe. It is better to designate azimuth only because the target tracking radar operators may be able to acquire the target before it becomes visible to you, if it becomes visible at all.

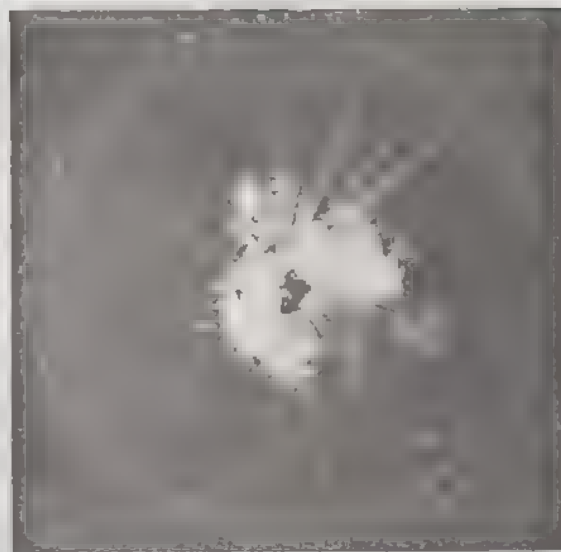
d. Direct Noise. Direct noise jamming will appear similar to noise amplitude modulated jamming, but is more effective because of its generally higher quality and wider frequency coverage (fig. 24). You may suspect that direct noise rather than modulated cw jamming is being used if you are unsuccessful in evading the jamming by changing frequency. The best action to take is to use the IS and change frequency, tuning for holes in the jamming. If all attempts to see the target through the jamming

TM 9-1430-250-10/3



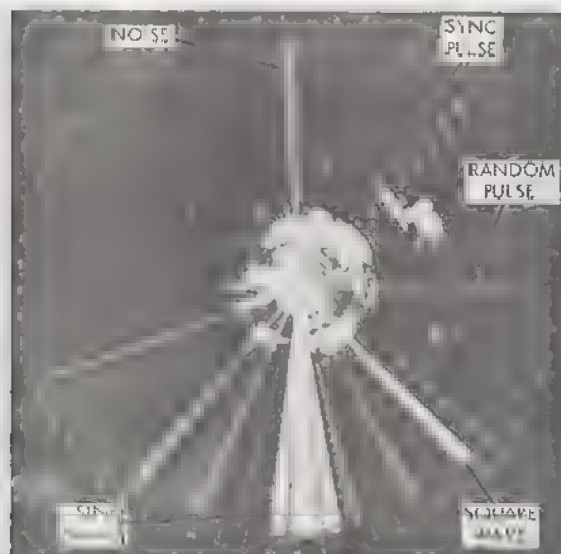
ORD G 46017

Figure 21. Noise amplitude modulated jamming on PPI.



ORD G 46006

Figure 22. Noise frequency modulated jamming on PPI.



ORD G 46018

Figure 23. Multiple jamming signals on PPI.



ORD G 46003

Figure 24. Direct noise jamming on PPI.



Figure 25 (CMHA). Swept frequency jamming on PPI, fast rate. (U)

fail, use the strobe line technique to designate the target.

e. Swept Frequency. Swept frequency jamming is an obscuration technique used when the jamming signal is swept through a wide band of frequencies at a fast rate. The effect on the PPI is shown in figure 25. Notice that the strobing pattern is not as random as it was for the confusion technique (fig. 16). Against a rapidly swept jamming signal, your best ECCM action is the use of the interference suppressor. Again, if you are unable to see through the jamming, use the strobe line technique to designate the target.

23.1 (CMHA). Obscuration Techniques (NIKE-HERCULES Systems with AJD)

Note For a discussion of the deception and confusion techniques, refer to paragraphs 21 and 22 *a* and *b*.

Discussed in this paragraph are the techniques the enemy may use to obscure the target returns on your PPI and PI and what you can do to combat these techniques. Obscuration techniques are those which are intended to hide the target (reflection techniques) or overpower the target return signals (transmission techniques).

a. Chaff Corridor. Chaff corridor implies the release of a steady stream of chaff by a lead plane in an attacking formation. As the chaff disperses it forms a corridor or cloud through, or behind, which the formation may fly (fig. 17). If the chaff is employed efficiently by the enemy, you will have much difficulty in seeing the targets and you should attempt to rid your indicators of the chaff returns. The MTI and interference suppressor circuits will probably be most effective against the chaff. The AJD and processor circuits will not aid you in combatting this type of obscuring technique. However, the use of the EXPANSION and EXPANDED POSITION controls of the PPI may help in detecting targets in the chaff cloud but should be used sparingly since they cause obscuration of a large portion of the normal presentation. The boundaries of the chaff corridor should also be watched for targets which may wander out of concealment. If attempts to nullify the effects of the chaff are unsuccessful you can designate the range and azimuth of the chaff-infested area to the target tracking radar, and the target tracking radar operators may be able to acquire targets within the chaff area.

b. Unmodulated CW. Unmodulated cw jamming is more severe than modulated cw. This type of jamming will present a strobe through the strobe channel. If the jamming frequency is within the wide bandpass of the receiver but not in the narrow bandpass, you will see cw capture on the PPI. This type jamming is more recognizable by its effects than by the jamming signal itself. Little or no indication of jamming, except the jamming strobe, will be visible on the PPI. Targets as well as ground clutter will fade out along the azimuth of the jammer. The AJD features will aid in combatting this type of jamming. If the video is still degraded, the processor can be used. Figure 11.3 shows a sequence of first setting the AJD switch to the on (up) position and then the PROC switch to the on (up) position. If this effect still persists, a change in frequency may aid in evading the jammer. If the jamming frequency is within the narrow bandpass and stronger than target returns, you will notice noise in a wedge-shaped area in all ranges and

absences of targets and clutter. A change in frequency may aid in combatting this type of jamming. Figure 25.2 shows the effects of on-frequency jamming. During on-frequency jamming the strobe can be used to designate the azimuth of the jammer to the TTR. If multiple strobes occur, the JS ONLY switch may be used

c. Modulated CW. A cw signal can be amplitude or frequency modulated with a variety of waveshapes. To have any effect on your PPI presentation the jamming signal must be in your frequency bandpass or pass through your frequency bandpass. You will always obtain a strobe during this type of jamming when the AJD switch is set to the on (up) position. The strobe can be used to designate the jammer's azimuth to the TTR. If the video appears degraded, the processor can be used. The effects of these jamming signals will be the same as discussed in *b* above. If the jamming signal is in the wide bandpass but not in the narrow bandpass, you will see cw capture. If the jamming frequency is within the narrow bandpass, you can change frequency and attempt to evade the jammer

d. Direct Noise. Direct noise jamming will appear similar to noise-amplitude modulated jamming, but has no effect on this system when the AJD and processor circuits are used. The

Dicke-fix circuits remove this type of jamming. The only indication you would see is a strobe at the azimuth of the jammer. If the jamming signal is much greater than the target return, the target will be masked by the jamming signal. Normal strobe designation can be used to designate the azimuth to the TTR.

e. Swept Frequency. Swept frequency jamming is an obscuration technique used when the jamming signal is swept through a wide band of frequencies at a fast rate. The only effect of this type of jamming is when the swept frequency is within your bandpass. Your best combatting techniques are the AJD and processor features. You will see the strobe at the azimuth of the jamming target. CW capture will occur as the swept frequency passes through the wide bandpass. To combat this, the FAGC circuits are used. As the swept frequency passes the narrow bandpass, noise may be seen at the azimuth of the jammer on the indicator. By using the strobe technique you can designate the jammer azimuth to the TTR.

f. Pulse Amplitude Modulated CW. For a discussion of this type jamming on an AJD receiver, refer to paragraph 23.3c. The AJD and processor features can be used to combat this type jamming. If this jamming effect persists, a frequency change may aid in combatting this type jamming.

Section 1.1 (CMHA). ACQUISITION RADARS (IMPROVED NIKE-HERCULES RADAR SYSTEMS)

Note Refer to paragraphs 21 through 23.1 for the techniques used to combat ECM against the LOPAR system.

23.2 (CMHA). Deception Technique

In this paragraph we will discuss the techniques an enemy may use to present false information to the HIPAR and what you can do to combat these techniques. The most difficult part of combatting deception techniques is recognizing the deception itself. Therefore, once you recognize the deception, the false indications are merely clutter on your scopes. Since a false indication must closely resemble a true target indication, you cannot rely on appearance alone to determine a false target. Motion and changing appearance are the primary factors which enable you to determine if a return is false. In the following paragraphs we will discuss the characteristics of the various ECM

techniques and give the most effective measures for combatting them.

a. Spot Chaff, Corner Reflectors, and Rope. The deceptive quality of these devices is short-lived and can be eliminated. The returns from these devices appear suddenly, as if the aircraft had maintained invisibility until it was within a certain range. The sudden appearance of additional targets in the vicinity of an already visible aircraft indicates that these returns are not real aircraft. However, the indication may be that of a real aircraft employing the pop-up tactic. If the new targets travel much slower than the aircraft, they are reflection devices. Chaff can be further identified by the increasing size of the return as the

chaff disperses. The effects of chaff are greatly diminished by the automatic built-in ECCM features of the HIPAR system. The effects of chaff at close ranges may be removed by setting the CLUTTER GATE switch to the ALL RANGE position. This provides noncoho MTI video or integrated video over the entire scope area. The aided range method will aid you in tracking through chaff.

b. Decoys. For the discussion of decoys refer to paragraph 21b.

c. Spoofers. An aircraft employing the spoofing technique is using your radar's transmitted pulse to trigger a transmission jammer that will transmit one or more pulses which will appear as pairs of additional targets on the indicator. The jamming target will always present only one return. These false return targets may be offset in range and/or azimuth from the true target. For a thorough discussion of identifying spoofer returns, refer to paragraph 21c (2) through (5). By alternately switching between the STAGGER OFF and NORMAL positions of the DISPLAY switch, you will be able to determine which of these returns are the targets.

23.3 (CMHA). Confusion Techniques

In this paragraph we will discuss the techniques the enemy may use to confuse you by making you uncertain as to which is the true target among many returns. Methods of combatting these techniques are also discussed. The primary difference between deception and confusion techniques is that confusion techniques leave no doubt that the enemy is employing ECM against you.

a. Chaff, Corner Reflectors, and Rope. The primary purpose of these devices is to confuse. When used in this capacity, they will be used in great number to cause numerous false targets on your indicator (fig. 13). In this manner, the enemy attempts to prevent you from maintaining a track on the aircraft as it flies through the area infested with reflecting devices. New methods of using these devices are constantly being developed. You can expect a lead aircraft in a formation to dispense the devices to provide protection for the remainder of the attacking force; or a single aircraft may dispense the devices in various ways to provide

self-protection. Even though these devices slow down and begin falling once released from the aircraft, aircraft flying through a dense concentration of these devices, especially chaff, may be difficult to track if it makes changes in its course and speed. The noncoho MTI feature aids in combatting large clouds of chaff. To aid in eliminating chaff in the coho MTI area, you may use the ALL RANGE position of the DISPLAY switch. In this position coho MTI is replaced by noncoho or integrated video. The aided range method will aid you in tracking through chaff.

b. Spoofers. Refer to the discussion in paragraph 21c. When the enemy generates many spoofer targets, the effect becomes confusion rather than deception (fig. 11.16). It may become obvious that all these returns are not from aircraft, but it may be very difficult to keep track of the aircraft returns among the numerous false returns. To combat this technique, you can use the stagger off mode of operation. Spoofer returns will appear as two false targets slightly separated in range. The reflected return for targets will present only one return on the PPI. When the DISPLAY switch is set to the STAGGER OFF position, only one of the pair of spoofer signals will be presented. This capability provides a means for you to distinguish spoofers from the jammer.

c. Pulse Amplitude Modulated CW. The effects of pulse modulated cw depend on whether the pulses are synchronized or nonsynchronized with the radar pulse repetition frequency. If the pulses are synchronized and are at a frequency within the narrow bandpass, they will affect the PPI by causing one or more circles or portions of circles (arcs), similar to the range circle, to appear. They will be similar to those shown in figure 15. If the pulses are nonsynchronized, and are at a frequency in the narrow bandpass, they will cause spiral strobos, called rabbits, to appear on the PPI as shown in figure 15. The pulses may also be varied in and out of synchronization. This technique will produce circles similar to those shown in figure 15 but thicker and less well defined. The thickness of the lines will depend on the extent the pulses are varied from synchronization. If the frequency of the synchronized or

nonsynchronized pulse is in the wide bandpass but is not in the narrow bandpass, cw capture will occur if the power levels of the jamming signals are great enough. This capture will present a darker wedge about the azimuth of the jammer. In the cases mentioned above, a strobe to the jammer will be painted by the strobe channel. In this type of jamming environment you will know the azimuths to the jammer. In any case, the indications on the PPI do not resemble targets but are meant to clutter the indicator and distract your attention. If the circles or rabbits become very dense, the target may be intermittently concealed, but it is unlikely that the enemy could generate enough interference by this technique alone to cause you serious trouble in tracking a target. If you wish to rid yourself of this type of jamming, a frequency change or radar selection change may be required.

d. *Swept Frequency.* Swept frequency jamming is a confusion device; the jamming signals are swept through a large band of frequencies at a slow rate. The effects of this type of jamming would only be noticed when the transmitted frequency of the jammer is within the wide bandpass of the receiver. You would notice cw capture, this would be indicated by a blank presentation past the preset range of the coho MTI. The best ECCM device to combat this type of jamming is the FAGC circuit. The main receiver FAGC may be utilized by setting the CLUTTER GATE switch to the OFF position. Figure 11.14 shows the effects of this switching.

23.4 (CMHA). Obscuration Techniques

In this paragraph we will discuss techniques the enemy may use to obscure the target returns on your indicators, and what you can do to operate against these techniques. Obscuration techniques are those which are intended to hide the target (reflection techniques) or overpower the target return signals (transmission techniques).

a. *Chaff Corridor.* Chaff corridor implies the release of a steady stream of chaff by a lead aircraft in an attacking formation. As the chaff disperses it forms a corridor or cloud through, or behind, which the formation may fly. The effects of this type ECM is greatly

reduced by the built-in ECCM features of the HIPAR. The noncoho video circuits using clutter gating will remove any chaff cloud that has a duration of longer than 9 microseconds. Figure 11.12 shows the effects of clutter gating a chaff cloud. When a specific target has been selected for engagement, you can use the EXPANSION and EXPANSION POSITION controls on the PPI. Figure 25.1 shows the effects of the expanded sweep on chaff.

b. *Unmodulated CW.* Unmodulated cw jamming is more severe than modulated cw. This type of jamming will present a strobe through the strobe channel. If the jamming frequency is within the wide bandpass of the receiver but not in the narrow bandpass, you will see cw capture on the PPI. Figure 11.14 shows the effects of cw capture. This type of jamming is recognizable more by its effects than by the jamming signal itself. Little or no indication of jamming will be visible on the PPI except the jamming strobe. Targets as well as ground clutter will fade out along the azimuth of the jammer. The use of the main receiver FAGC will combat this type of jamming. You can select the FAGC by setting the CLUTTER



ORD G258016

Figure 25.1 (CMHA). Effects of expanded sweep on clutter gated chaff cloud. (U)

GATE switch to the OFF position. If the jamming frequency is within the narrow bandpass and stronger than target returns, you will notice noise in a wedge-shaped area in all ranges and obscuration of targets and some clutter. During on-frequency jamming the strobe can be used to designate the azimuth of the jammer to the TTR. If you wish to rid yourself of this type of jamming, a frequency change or radar selection change may be required. Figure 25.2 shows the effects of on-frequency jamming.

c. Modulated CW. A cw signal can be amplitude or frequency modulated with a variety of wave shapes. To have any effect on your PPI presentation the jamming signal must be in your frequency bandpass or pass through your frequency bandpass. You will always obtain a strobe during this type of jamming. The strobe can be used to designate the jammer's azimuth to the TTR. The effects of these jamming signals will be the same as discussed in paragraph 23.1c. If the signal is in the wide bandpass but not in the narrow bandpass, you will see cw capture. The main receiver FAGC is the best ECCM device to eliminate this. If the jamming frequency is within the narrow bandpass you can select the LOPAR and change frequency.

d. Direct Noise. Direct noise jamming will appear similar to noise amplitude modulated jamming, but has no effect on this system. The Dicke-fix circuits remove this type of jamming. The only indication would be a strobe at the azimuth of the jammer. If the jamming signal is much greater than the target return, the target will be masked by the jamming signal but the strobe can be designated to the TTR.

e. Swept Frequency. Swept frequency jamming is an obscuration technique used when the jamming signal is swept through a wide band of frequencies at a fast rate. The only effect of this type of jamming is when the swept frequency is within your bandpass. You will see the strobe at the azimuth of the jamming target. CW capture will occur as the swept frequency passes through the wide bandpass. To combat this, the main receiver FAGC can be used. As the swept frequency passes the



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Figure 25.2 (CMHA). Effects of on-frequency jamming on the PPI.

narrow bandpass, noise may be seen at the azimuth of the jammer on the indicator. By using the strobe technique you can designate the jammer azimuth to the TTR.

Section 1.2 (CMHA). ACQUISITION RADARS (NIKE-HERCULES ANTI-TACTICAL BALLISTIC MISSILE SYSTEMS)

23.5 (CMHA). Obscuration Techniques
(LOPAR of ATBM System)

Note. For a discussion of the deception and confusion techniques, refer to paragraphs 21 and 22.

Discussed in this paragraph are the techniques the enemy may use to obscure the target returns on your PPI's and what you can do to combat these techniques. Obscuration techniques are those which are intended to hide the target (reflection techniques) or overpower the target return signals (transmission techniques).

a. *Chaff Corridor.* Chaff corridor implies the release of a steady stream of chaff by a lead plane in an attacking formation. As the chaff disperses, it forms a corridor or cloud through, or behind, which the formation may fly (fig. 17). If the chaff is employed efficiently by the enemy, you will have much difficulty in seeing the targets, and you should attempt to rid your indicators of the chaff returns. The MTI and interference suppressor circuits will probably be most effective against the chaff. The AJD and processor circuits will not aid you in combatting this type of obscuring technique. The boundaries of the chaff corridor should also be watched for targets which may wander out of concealment. If attempts to nullify the effects of the chaff are unsuccessful, you can designate the range and azimuth of the chaff-infested area to the target tracking radar, and the target tracking radar operators may be able to acquire targets within the chaff area.

b. *Unmodulated CW.* Unmodulated cw jamming is more severe than modulated cw. This type of jamming will present a strobe through the strobe channel. If the jamming frequency is within the wide bandpass of the receiver but not in the narrow bandpass, you will see cw capture on the PPI's. This type of jamming is more recognizable by its effects than by the jamming signal itself. Little or no indication of jamming, except the jamming strobe, will be visible on the PPI's. Targets, as well as ground clutter, will fade out along the azimuth of the jammer. The AJD features will aid in combatting this type of jamming. If the video is still degraded, the processor can be used. Figure 11.3 shows a sequence of first selecting the

AJD receiver and then the processor circuits. If this effect still persists, a change in frequency may aid in evading the jammer. If the jamming frequency is within the narrow bandpass and stronger than target returns, you will notice noise in a wedge-shaped area in all ranges and absences of targets and clutter. A change in frequency may aid in combatting this type of jamming. Figure 25.2 shows the effects of on-frequency jamming. During on-frequency jamming, the strobe can be used to designate the azimuth of the jammer to the TTR. If multiple strobes occur, the JS ONLY RECEIVER switch-indicator may be used only for strobe information.

c. *Modulated CW.* A cw signal can be amplitude or frequency modulated with a variety of waveshapes. To have any effect on your PPI presentation, the jamming signal must be in your frequency bandpass or must pass through your frequency bandpass. You will always obtain a strobe during this type of jamming when the AJD receiver is selected. The strobe can be used to designate the jammer's azimuth to the TTR. If the video appears degraded, the processor can be used. The effects of these jamming signals will be the same as discussed in b above. If the jamming signal is in the wide bandpass but not in the narrow bandpass, you will see cw capture. If the jamming frequency is within the narrow bandpass, you can change frequency and attempt to evade the jammer.

d. *Direct Noise.* Direct noise jamming will appear similar to noise-amplitude modulated jamming, but has no effect on this system when the AJD and processor circuits are used. The Dicke-fix circuits remove this type of jamming. The only indication you will see is a strobe at the azimuth of the jammer. If the jamming signal is much greater than the target return, the target will be masked by the jamming signal. Normal strobe designation can be used to designate the azimuth to the TTR.

e. *Swept Frequency.* Swept frequency jamming is an obscuration technique used when the jamming signal is swept through a wide band of frequencies at a fast rate. The only effect of this type of jamming is when the swept fre-

quency is within your bandpass. Your best combatting techniques are the AJD and processor features. You will see the strobe at the azimuth of the jamming target. CW capture will occur as the swept frequency passes through the wide bandpass. To combat this, the FAGC circuits are used. As the swept frequency passes the narrow bandpass, noise may be seen at the azimuth of the jammer on the indicator. By using the strobe technique you can designate the jammer's azimuth to the TTR.

f. Pulse Amplitude Modulated CW. For a discussion of this type of jamming on an AJD receiver, refer to paragraph 23.3c. The AJD and processor features can be used to combat this type of jamming. If this jamming effect persists, a frequency change may aid in combatting this type of jamming.

23.6 (CMHA). EFS/ATBM HIPAR Deception Techniques

In this paragraph we will discuss the techniques an enemy may use to present false information to the EFS/ATBM HIPAR and what you can do to combat these techniques. The most difficult part of combatting deception techniques is recognizing the deception itself. Therefore, once you recognize the deception, the false indications are merely clutter on your scopes. Since a false indication will closely resemble a true target indication, you cannot rely on appearance alone to determine a false target. Motion and changing appearance are the primary factors which enable you to determine if a return is false. In the following paragraphs we will discuss the characteristics of the various ECM techniques and give the most effective measures for combatting them.

a. Spot Chaff, Corner Reflectors, and Rope. The deceptive quality of these devices is short-lived and can be eliminated. The returns from these devices appear suddenly, as if the aircraft had maintained invisibility until it was within a certain range. The sudden appearance of additional targets in the vicinity of an already visible aircraft indicates that these returns are not real aircraft. However, the indication may be that of a real aircraft employing the pop-up tactic. If the new targets travel much slower than the aircraft, they are reflection devices. Chaff can be further identified by the increasing

size of the return as the chaff disperses. The effects of chaff are greatly diminished by the automatic built-in ECCM features of the EFS/ATBM HIPAR system. The effects of chaff at close ranges may be removed by selecting the clutter gate all range mode of operation. This provides noncoho MTI video or integrated video over the entire scope area.

b. Decoys. For a discussion of decoys, refer to paragraph 21b.

c. Spoofers An aircraft employing the spoofing technique is using your radar's transmitted pulse to trigger a transmission jammer that will transmit one or more pulses which will appear as pairs of additional targets on the indicator. The jamming target will always present only one return. These false return targets may be offset in range and/or azimuth from the true target. For a thorough discussion of identifying spoofer returns, refer to paragraph 21c(2) through (5). By alternately depressing and releasing the STAGGER OFF switch-indicator, you will be able to determine which of these returns are the targets.

23.7 (CMHA). EFS/ATBM HIPAR Confusion Techniques

In this paragraph we will discuss the techniques the enemy may use to confuse you by making you uncertain as to which is the true target among many returns. Methods of combatting these techniques are also discussed. The primary difference between deception and confusion techniques is that confusion techniques leave no doubt that the enemy is employing ECM against you.

a. Chaff, Corner Reflectors, and Rope. The primary purpose of these devices is to confuse. When used in this capacity, they will be used in great number to cause numerous false targets on your indicator (fig. 13). In this manner, the enemy attempts to prevent you from designating a target as it flies through the area infested with reflecting devices. New methods of using these devices are constantly being developed. You can expect a lead aircraft in a formation to dispense the devices to provide protection for the remainder of the attacking force; or a single aircraft may dispense the devices in various ways to provide self-protection. Even though these devices slow down and begin falling once

released from the aircraft, aircraft flying through a dense concentration of these devices, especially chaff, may be difficult to designate if it makes changes in its course and speed. The noncoho MTI feature aids in combatting large clouds of chaff. To aid in eliminating chaff in the coho MTI area, you may use the clutter gate all range mode of operation. In this position coho MTI is replaced by noncoho or integrated video.

b. Spoofers. Refer to the discussion in paragraph 21c. When the enemy generates many spoofer targets, the effect becomes confusion rather than deception (fig. 11.16). It may become obvious that all these returns are not from aircraft, but it may be very difficult to distinguish a target among the numerous false returns. To combat this technique, you can use the stagger off mode of operation. Spoofer returns will appear as two false targets slightly separated in range. The reflected return for targets will present only one return on the PPI. When the STAGGER OFF switch-indicator is depressed, only one spoofer signal will be presented. This capability provides a means for you to distinguish spoofers from the target.

c. Pulse Amplitude Modulated CW. The effects of pulse modulated cw depend on whether the pulses are synchronized or nonsynchronized with the radar pulse repetition frequency. If the pulses are synchronized and are at a frequency within the narrow bandpass, they will affect the PPI's by causing one or more circles or portions of circles (arcs), similar to the range circle, to appear. They will be similar to those shown in figure 15. If the pulses are nonsynchronized and are at a frequency in the narrow bandpass, they will cause spiral strobes called rabbits to appear on the PPI's, as shown in figure 15. The pulses may also be varied in and out of synchronization. This technique will produce circles similar to those shown in figure 15 but thicker and less well defined. The thickness of the lines will depend on the extent the pulses are varied from synchronization. If the frequency of the synchronized or nonsynchronized pulse is in the wide bandpass but is not in the narrow bandpass, cw capture will occur if the power levels of the jamming signals are great enough. This capture will present a darker wedge about the azimuth of the jammer.

In the cases mentioned above, a strobe to the jammer will be painted by the strobe channel. In this type of jamming environment you will know the azimuth to the jammer. In any case, the indications on the PPI's do not resemble targets but are meant to clutter the indicator and distract your attention. If the circles or rabbits become very dense, the target may be intermittently concealed, but it is unlikely that the enemy could generate enough interference by this technique alone to cause you serious trouble in detecting a target. If you wish to rid yourself of this type of jamming, change frequency and if necessary a radar selection change may be required.

d. Swept Frequency. Swept frequency jamming is a confusion device; the jamming signals are swept through a large band of frequencies at a slow rate. The effects of this type of jamming would only be noticed when the transmitted frequency of the jammer is within the wide bandpass of the receiver. You would notice cw capture, which would be indicated by a blank presentation past the preset range of the coho MTI. The best ECCM device to combat this type of jamming is the FAGC circuit. The main receiver FAGC may be utilized by selecting the clutter gate off mode of operation. Figure 11.14 shows the effects of this switching. If slow sweep or narrow-swept band jamming is used a frequency change may be used and if necessary a radar selection change may be required.

23.8 (CMHA). EFS/ATBM HIPAR Obscuration Techniques

In this paragraph we will discuss techniques the enemy may use to obscure the target returns on your indicators and what you can do to combat these techniques. Obscuration techniques are those which are intended to hide the target (reflection techniques) or overpower the target return signals (transmission techniques).

a. Chaff Corridor. Chaff corridor implies the release of a steady stream of chaff by a lead aircraft in an attacking formation. As the chaff disperses, it forms a corridor or cloud through, or behind, which the formation may fly. The effect of this type of ECM is greatly reduced by the built-in ECCM features of the EFS/ATBM HIPAR. The noncoho video circuits using clut-

ter gating will remove any chaff cloud that has a duration of longer than 9 microseconds. Figure 11.12 shows the effects of clutter gating a chaff cloud.

b. Unmodulated CW. Unmodulated cw jamming is more severe than modulated cw. This type of jamming will present a strobe through the strobe channel. If the jamming frequency is within the wide bandpass of the receiver but not in the narrow bandpass, you will see cw capture on the PPI's. Figure 11.14 shows the effects of cw capture. This type of jamming is recognizable more by its effects than by the jamming signal itself. Little or no indication of jamming will be visible on the PPI's except the jamming strobe. Targets, as well as ground clutter, will fade out along the azimuth of the jammer. The use of the main receiver FAGC will combat this type of jamming. You can select the FAGC by selecting the clutter gate off mode of operation. If the jamming frequency is within the narrow bandpass and stronger than target returns, you will notice noise in a wedge-shaped area in all ranges, obscuration of targets, and some clutter. During on-frequency jamming, the strobe can be used to designate the azimuth of the jammer to the TTR. If you wish to rid yourself of this type of jamming, change frequency and if necessary a radar selection change may be required. Figure 25.2 shows the effects of on-frequency jamming.

c. Modulated CW. A cw signal can be amplitude or frequency modulated with a variety of wave shapes. To have any effect on your PPI presentation, the jamming signal must be in your frequency bandpass or must pass through your frequency bandpass. You will always obtain a strobe during this type of jamming. The

strobe can be used to designate the jammer's azimuth to the TTR. The effects of these jamming signals will be the same as discussed in paragraph 23.1c. If the signal is in the wide bandpass but not in the narrow bandpass, you will see cw capture. The main receiver FAGC is the best ECCM device to eliminate this. If the jamming frequency is within the narrow bandpass, you can change frequency and if necessary a radar selection change may be required.

d. Direct Noise. Direct noise jamming will appear similar to noise amplitude modulated jamming, but has little effect on this system. The Dicke-fix circuits minimize this type of jamming. The only indication would be a strobe at the azimuth of the jammer. If the jamming signal is much greater than the target return, the target will be masked by the jamming signal, but the strobe can be designated to the TTR. To aid combatting this type of jamming, you can change frequency and if necessary a radar selection change may be required.

e. Swept Frequency. Swept frequency jamming is an obscuration technique used when the jamming signal is swept through a wide band of frequencies at a fast rate. The only effect of this type of jamming is when the swept frequency is within your bandpass. You will see the strobe at the azimuth of the jamming target. CW capture will occur as the swept frequency passes through the wide bandpass. To combat this, the main receiver FAGC can be used. As the swept frequency passes the narrow bandpass, noise may be seen at the azimuth of the jammer on the indicator. By using the strobe technique, you can designate the jammer's azimuth to the TTR.

Section II (CMHA). TARGET TRACKING RADAR (NIKE-AJAX AND NIKE-HERCULES SYSTEMS)

24 (CMHA). Deception Techniques

This paragraph discusses techniques the enemy may use to present false information to the target tracking radar in such a way that you do not recognize it as false information. What you can do to offset the deceptive quality and operate against these techniques is also discussed. The most important and most difficult part of combatting deception techniques is being able to recognize the deception itself. It is more

difficult to recognize deception against this radar compared to the acquisition radar. This is true for two reasons. The target tracking radar "sees" a very small volume of space at any one time and is thus unable to provide you with an over-all picture which may be helpful in recognizing deception ECM. Secondly, since this type radar poses the most direct and imminent threat to attacking aircraft, it can be assumed that more effort has been expended in



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Figure 26 (CMHA) Spoofers on tracking indicator (U).

the development of sophisticated deception techniques to be used against it. Your battle is not completely won upon recognition of the deception because of the limited "field of vision" of your radar. As you will see in the following techniques, the deception, once recognized, may give way to very effective confusion resulting in tracking difficulty and may even cause you to lose the target. The effects of deception ECM techniques on your indicators will present seemingly normal indications. You must depend on close continuous observation of your indicators for indications that the enemy is employing deception ECM.

a. Spot Chaff, Corner Reflectors, Rope, and Spoofers. It is possible that a return from any of these reflecting devices or a spoofer return will deceive you, especially if you initially lock on this return instead of the aircraft. Figure 26 shows typical spoofed returns as viewed on a tracking indicator (A scope). Good teamwork between you and the acquisition radar operator can eliminate this possibility or at least quickly

offset the deception. These four devices (spot chaff, corner reflectors, rope, and spoofers) or techniques have one thing in common: your best ECCM technique against them is the use of the acquisition radar operator, your PPI, and PI. This is true for at least one of two reasons. The PPI and PI enable you or the acquisition radar operator to detect the relatively slow motion of reflecting devices much easier than by observation of the tracking indicators. Secondly, in the case of chaff or a spoofer, the return may be non-existent on the PPI or PI. Thus, if you lock on a target and, by observation of the PPI or PI, you note that it does not have characteristics of an aircraft or is not present on the PPI or PI, you can disregard the return. It should be mentioned here that rope is not normally designed for use against tracking radars, but the width dimension may cause a return to the target tracking radar.

b. Decoys. Since decoys have flight characteristics similar to real aircraft and are equally visible to the acquisition and target tracking radars, they are more effective deception devices than those discussed in *a* above. If the acquisition radar operator is deceived and designates the decoy to you, there is no way you can know that you are tracking a false target. However, an aircraft may launch a decoy after you have begun tracking. This technique will be evident to you as the one target gradually separates into two. It will still be difficult to determine which is the decoy because the decoy may lead or lag the aircraft and will probably be designed to have a radar cross-section equal to that of the launching aircraft. One possible means of continuing the track of the real target is to maintain the same aided rate established prior to the appearance of the second return. You can expect the decoy to be equipped with a jamming transmitter to further complicate the environment.

c. Range Gate Stealing. Using this technique, the enemy attempts to introduce range tracking errors by displacing the range gate from the target. The enemy retransmits the

radar pulse with minimum delay and at a relatively low power level. He then slowly increases the power of the retransmitted pulse to capture automatic gain control. If the retransmitted pulse power is increased to a certain extent, the automatic gain control may decrease the gain of the receiver enough to make the target echo invisible on your indicators. The enemy then slowly adds more and more delay time in the retransmission of subsequent pulses and you will track this false target if the target echo has successfully been made invisible. If the enemy continues to retransmit the radar pulses with some delay, you will be entering a continuous range error into the computer. If the enemy suddenly ceases retransmission after stealing the range gate away from the real target echo, he will have succeeded in breaking your lock on the target. The automatic gain control is no longer controlled by the retransmitted pulse and the target should be visible on your range sweep since the antenna probably will still be pointing at the target in azimuth and elevation. Whether or not you will detect this jamming operation depends primarily on the quality of the jammer. Unless the jammer accomplishes the range gate stealing very smoothly, you may see abnormal fluctuations in the noise on your indicators as the jamming signal captures automatic gain control. The jamming signal may not reduce receiver gain enough to make the target echo invisible and you may thus see what appears to be a small target as the jammer increases the delay of the retransmitted pulse. This small target may be the aircraft. If you suspect that this technique is being used, your best ECCM action is the dump and tune procedure. You should be in the aided rate mode of operation. This mode of operation will at least prevent the radar from automatically tracking the more powerful deception pulse. During any tracking

operation observe the PI to determine range difference.

d. Blinking. Blinking is a technique of retransmitting the radar pulses from opposite extremities of the aircraft alternately. This technique will cause the antenna to oscillate or hunt back and forth over the aircraft if you are tracking in automatic. By operating in the aided rate mode, you can eliminate this technique as a potential threat. However, we will consider the consequences of this technique if you are tracking automatically at the time it is initiated. This technique does not conform exactly to our definition of deception except that your indicators will present a normal indication. However, antenna oscillations will be indicated on the angle error meters. The deceptive quality of the technique relies on the assumption that you will mistake the oscillations for a normal condition, since the radar will normally hunt over a large aircraft to some extent, or that you will believe the oscillation to be caused by a malfunction in the radar itself. It is difficult for the enemy to gain enough information from the radar to make this technique effective against even an automatically tracking radar. The enemy must have continuous information on the precise behavior of the antenna to program his two transmitters. At best, this technique will cause the antenna to increase oscillation until it slews completely off target. As stated above, tracking in the aided rate mode of operation will effectively combat this technique.

25. (CMHA) Confusion Techniques

In this paragraph we will discuss techniques the enemy may use to confuse you by cluttering your indicators or by making you uncertain as to which is the real target among many false targets. What you can do to operate against these techniques is also discussed.

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a. Chaff and Corner Reflectors. The enemy may attempt to confuse you by launching numerous bundles of chaff in all directions or by dropping corner reflectors so that there are many target returns in the vicinity of the aircraft. In time you should be able to identify the aircraft return primarily by its speed, but the time lost in the process may be valuable. You can assume that chaff will be used more commonly than corner reflectors since it falls more slowly and thus remains within the radar beam for a longer period of time. Chaff may also be released from the aircraft after you have begun tracking. As the chaff disperses, the returns from it lose their similarity to the aircraft return, slow down, and become large and indistinct. In the case of chaff released to the rear of the aircraft, you should track the leading edge of the chaff clutter. By this means you will be tracking the aircraft, although the aircraft may not be distinguishable from the chaff return. In the case of forward-launched or side-launched chaff, you may more readily become confused and begin tracking a chaff return. (See figure 27.) The aircraft may be intermittently concealed as it flies amid the chaff. If you note that a radical change in your aided rate is required to maintain track, you should realize that you have probably lost the aircraft target and have begun tracking a chaff return. It would be best not to change an aided rate at all while the aircraft is temporarily concealed by chaff. Wait till the aircraft is again in the clear before making any necessary rate adjustments. You may be able to use the PI as an aid to tracking the aircraft through the chaff clutter. Depending upon the design of the chaff, it may have less or no effect on the acquisition radar and the PI may be clean of chaff returns.

b. Spoofers. The initial effect of spoofer targets will be approximately the same as that of spot chaff and corner reflectors. The spoofer

targets may leave you in doubt as to which is the real target. Although they offer an advantage to the enemy over reflecting devices because they maintain a realistic aircraft size and motion, they are more susceptible to ECCM action. The factors discussed in paragraph 21c generally apply to the recognition of spoofer targets on your tracking indicators. The best action is to use the dump and tune procedure. An additional means of identifying an aircraft among many spoofer returns is by observation of your PPI and PI in the event that the enemy is not generating spoofer targets against the acquisition radar at the same time. In this case use the PI to maintain range tracking.

c. Pulse Amplitude Modulated CW. Pulse modulated cw jamming signals produce what is commonly called railing on the tracking indicators. Railing consists of sharp spikes, similar in appearance to the radar transmitted pulse, appearing over the length of the range sweep. If the pulses are synchronized with the radar pulse repetition frequency the railing will remain stationary on the range sweep. Non-synchronized railing will move in or out in range. The density of the railing or number of spikes present depends on the pulse repetition frequency of the jamming pulses. You must remain in the aided rate mode to prevent locking on one of the jamming pulses. The dump and tune procedure should be effective in reducing the clutter on your indicators.

d. Swept Frequency. Swept frequency jamming is a confusion technique which consists of sweeping the jamming signal through a wide band of frequencies at a slow rate. The effect on the tracking indicator is the appearance of intermittent bursts of jamming signals. Figure 28 contains views of random, intermittent jamming signals as viewed on a tracking indicator. The duration of the burst and the spacing between them will be random. Because of this

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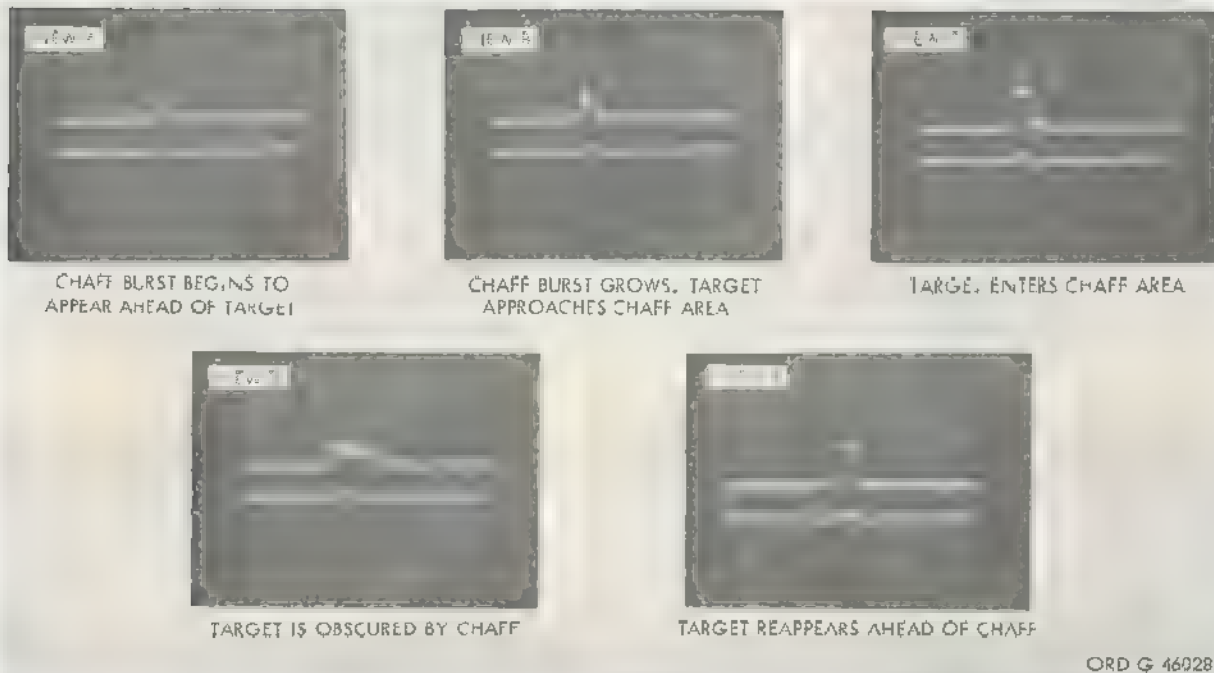


Figure 27. Forward-launched chaff on tracking indicator.

randomness the target is visible often enough to allow you to maintain a smooth track in the aided mode of operation.

26. (CMHA) Obscuration Techniques

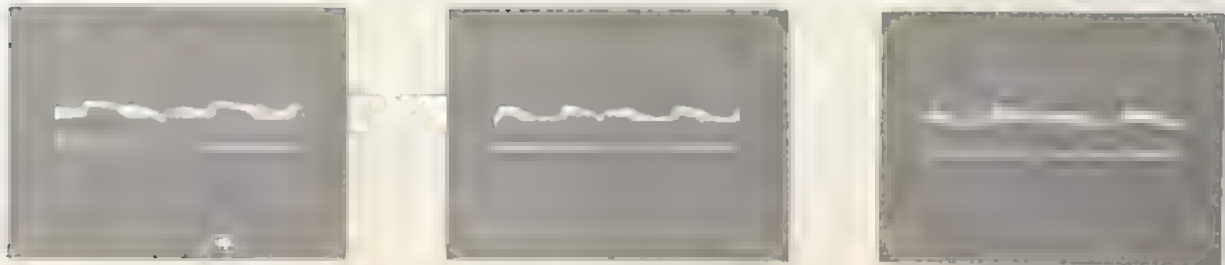
In this paragraph we will discuss techniques the enemy may use to obscure target returns on your indicators and prevent you from tracking an important target and what you can do to operate against these techniques. These obscuration techniques include the concealment of targets within or behind a cloud of chaff and the overpowering of target returns with transmission jamming.

a. Chaff Corridor. Against chaff corridor you may have to rely, to a great extent, on the PPI and PI as an aid in tracking a target,

assuming that the chaff has less effect on the acquisition radar. You should be able to track the chaff-launching aircraft on the tracking indicators by tracking the leading edge of the chaff drop. However, the chaff-launching aircraft is probably not the important target. The important targets may be effectively concealed by the clutter on the tracking indicators. Depending on the effectiveness of the chaff on the PPI and PI, you can use these indicators in one of two ways. If the chaff does not obscure the targets on the PPI and PI, you can maintain a track on the PI by using aided rate tracking. If the chaff is multiband, thereby obscuring the targets on the PPI and PI as well as the tracking indicators, you can search the edges of the chaff clutter as seen on the PPI

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Figure 28 Swept frequency jamming on tracking indicator, slow rate.

in the event that a target strays out of the concealment of the chaff.

b. Unmodulated CW. Unmodulated cw jamming tends to drive the receiver toward cutoff. An indication of this condition is a reduction in amplitude of the target and receiver noise on the tracking indicators. If powerful enough, this type jamming will reduce the amplitude of target video to a level that would be difficult to see on the indicators. Figure 29, views A through F, shows six different intensities of unmodulated cw jamming, the most intense (view F) reducing the target to imperceptible amplitude. Against this technique you should first operate the VIDEO AMP switch for added amplification. This action may present a usable video signal on the indicators. Figure 29, views G and H, show the effect of using added amplification to the target in view F. If this action is not effective, you should use the dump and tune procedure. If the enemy is not able to track your frequency changes, you should have little trouble evading the jamming frequency. If you are unsuccessful in obtaining a usable signal on the tracking indicators, use the PI to track the target in range.

c. Modulated CW. The various forms of modulated cw jamming have similar effects on

the tracking indicators. The exact effect of a given type of modulated cw jamming is unpredictable. The effect will be an obscuring clutter on the indicators which may or may not show the waveform of the modulating signal. Figure 30 shows a series of five typical sine wave modulated cw jamming signals (at five different modulation frequencies) as they appear on the tracking indicator. Figure 31 shows a series of five typical square wave modulated cw signals on the same indicator. Figure 32 shows random pulse modulated cw jamming at various pulse repetition frequencies. Initially, your ECCM action against all these techniques should be the dump and tune procedure. Depending on the effectiveness of the jamming in a particular situation, the VIDEO AMP switch may improve the presentation on the tracking indicators. Use of the VIDEO AMP switch has resulted in improved presentation under noise modulated cw conditions in views C and E, figure 33. Again, if all attempts to utilize the tracking indicators fail, you should attempt to obtain range information from the PI as the target tracking radar angle tracks the jamming signal.

d. Direct Noise. Direct noise may be indistinguishable from noise modulated cw. Thus you should employ the dump and tune pro-

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Figure 29. Unmodulated cw jamming on tracking indicator.

cedure. The results obtained by this procedure should then indicate that the jamming is direct noise and that you should tune for holes in the jamming spectrum. However, the characteristics of direct noise make it very difficult to combat. Therefore, you will probably have to depend on the PI for range information as the

target tracking radar angle tracks the jamming.

e. Swept Frequency. Swept frequency jamming is an obscuration technique which sweeps a jamming signal through a wide band of frequencies at a fast rate. The effect on the tracking indicator consists of bursts of jamming signals appearing along the range sweep. (See

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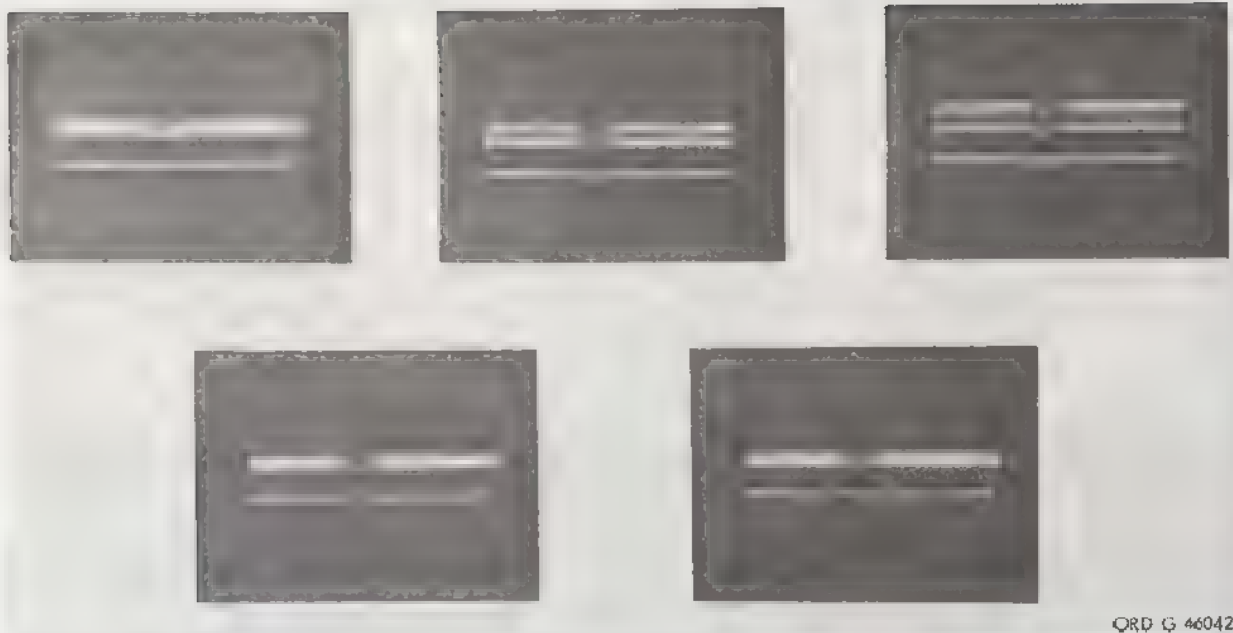


Figure 30. Sine wave modulated cw jamming on tracking indicator.

figure 34.) These bursts are usually close together, thus increasing the difficulty in tracking the target. The dump and tune procedure, as such, is not much help; but merely by tuning without interrupting transmission, you may

discover that the jamming signal is not being swept across the entire frequency band. There may be a portion of your frequency band within which you can operate without interference.

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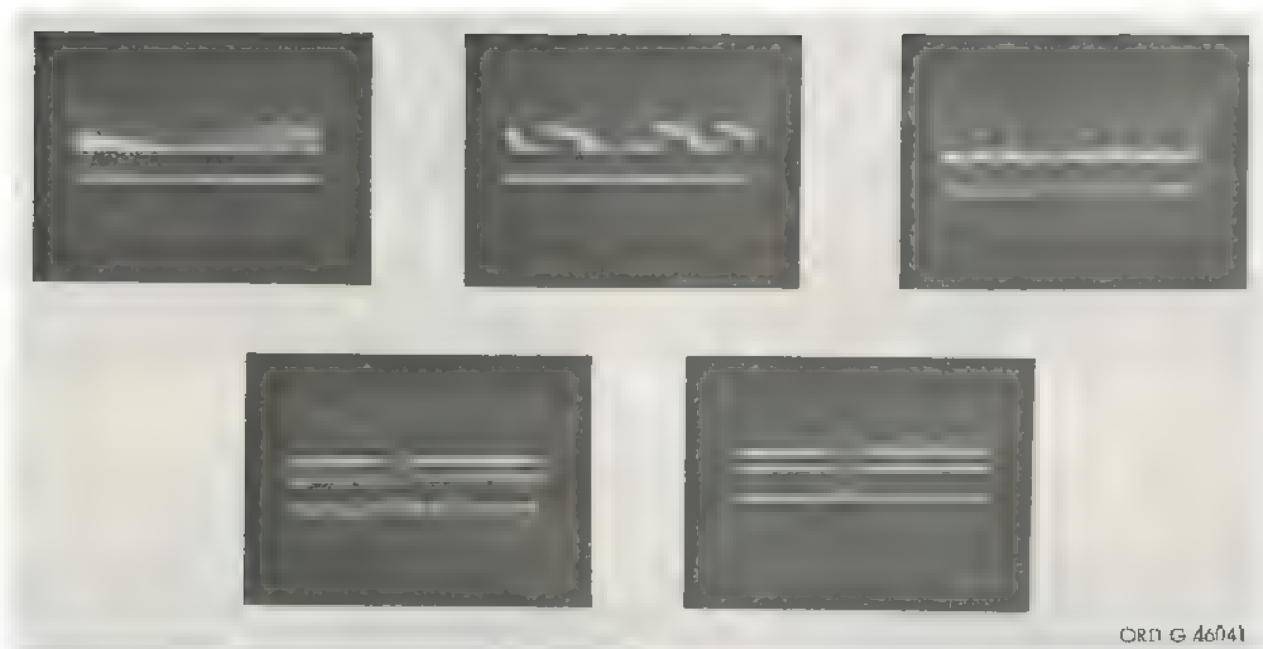


Figure 31. Square wave modulated cw jamming on tracking indicator.

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Figure 32. Random pulse modulated cw jamming on tracking indicator.

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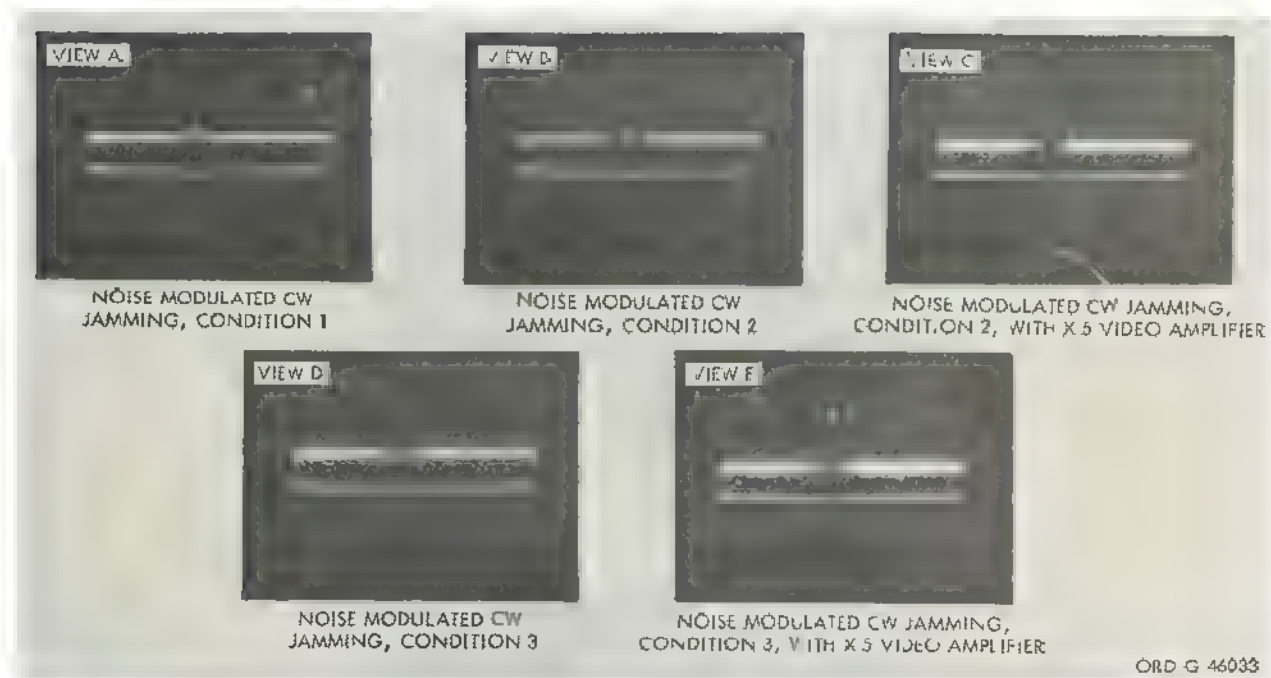
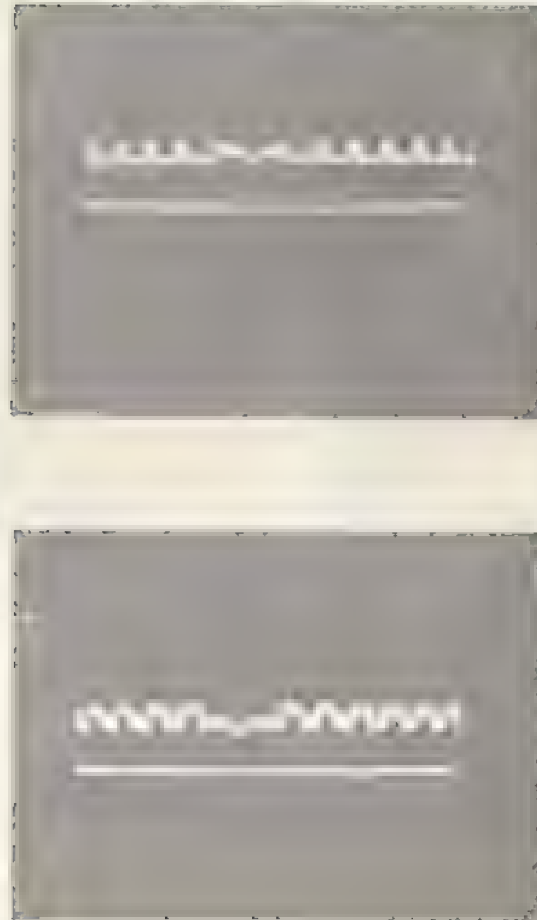


Figure 88 Noise modulated cw jamming on tracking indicator.

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Figure 24. Swept frequency jamming on tracking indicator, fast rate.

Section II.1 (CMHA). TRACKING RADARS (IMPROVED NIKE-HERCULES RADAR SYSTEMS)**26.1 (CMHA). Deception Techniques**

This paragraph discusses techniques the enemy may use to present false information to the target tracking radar (TTR) and target ranging radar (TRR) in such a way that you do not recognize it as false information. What you can do to offset the deceptive quality and operate against these techniques is also discussed. The most important and most difficult part of combatting deception techniques is being able to recognize the deception itself. It is more difficult to recognize deception against this radar compared to the acquisition radars. This is true for two reasons. The TTR and TRR "see" a very small volume of space at any one time, and therefore, are unable to provide you with an over-all picture which may be helpful in recognizing deception ECM. Secondly, since the tracking radar system poses the most direct and imminent threat to attacking aircraft, it can be assumed that more effort has been expended in the development of sophisticated deception techniques to be used against it. Your battle is not completely won upon recognition of the deception because of the limited "field of vision" of your radar system. As you will see in the following techniques, the deception, once recognized, may give way to very effective confusion resulting in tracking difficulty and may even cause you to lose the target. The effects of deception ECM techniques on your indicators will present seemingly normal indications. You must depend on close continuous observation of your indicators for indications that the enemy is employing deception ECM.

a. Spot Chaff, Corner Reflectors, Rope, and Spoofers. It is possible that a return from any of these reflecting devices or a spoofer return will deceive you, especially, if you initially lock on this return instead of the aircraft. Figure 26 shows typical spoofer returns as viewed on a tracking indicator (A scope). Good teamwork between you and the acquisition radar operator can eliminate this possibility or at least quickly offset the deception. These four devices (spot chaff, corner reflectors, rope, and spoofers) or techniques have one thing in common; your best ECCM technique against them is the use of the acquisition radar operator and your B

scope. This is true for at least one of two reasons. The B scope enables you to detect the relatively slow motion of reflecting devices much easier than by observation of the tracking indicators. Secondly, in the case of chaff or a spoofer, the return may be nonexistent on the B scope. Thus, if you lock on a target and, by observation of the B scope, you note that it does not have characteristics of an aircraft or is not present on the B scope, you can disregard the return. It should be mentioned here that rope is not normally designed for use against tracking radars, but the width dimension may cause a return to the tracking radar.

b. Decoys. Since decoys have flight characteristics similar to real aircraft and are equally visible to the acquisition radars, TTR, and TRR, they are more effective deception devices than those discussed in *a* above. If the acquisition radar operator is deceived and designates the decoy to you, there is no way you can know that you are tracking a false target. However, an aircraft may launch a decoy after you have begun tracking. This technique will be evident to you as the one target gradually separates into two. It will still be difficult to determine which is the decoy because the decoy may lead or lag the aircraft and will probably be designed to have a radar cross-section equal to that of the launching aircraft. One possible means of continuing the track of the real target is to maintain the same aided range rate established prior to the appearance of the second return. You may also switch the TRR to short pulse for better definition of the two targets. You can expect the decoy to be equipped with a jamming transmitter to further complicate the environment.

c. Range Gate Stealing. Using this technique, the enemy attempts to introduce range tracking errors by displacing the range gate from the target. The enemy retransmits the radar pulse with minimum delay and at a relatively-low power level. He then slowly increases the power of the retransmitted pulse to capture automatic gain control. If the retransmitted pulse power is increased to a certain extent, the automatic gain control may decrease the gain of the receiver enough to make

the target echo invisible on your indicators. The enemy then slowly adds more and more delay time in the retransmission of subsequent pulses and you will track this false target if the target echo has successfully been made invisible. If the enemy continues to retransmit the radar pulses with some delay, you will be entering a continuous range error into the computer. If the enemy suddenly ceases retransmission after stealing the range gate away from the real target echo, he will have succeeded in breaking your lock on the target. The automatic gain control is no longer controlled by the retransmitted pulse and the target should be visible on your range sweep since the antenna probably will still be pointing at the target in azimuth and elevation. Whether or not you will detect this jamming operation depends primarily on the quality of the jammer. Unless the jammer accomplishes the range gate stealing on both the TTR and TRR simultaneously and very smoothly, you may see abnormal fluctuations in the noise on your indicators as the jamming signal captures automatic gain control. The jamming signal may not reduce receiver gain enough to make the target echo invisible; therefore, you may see what appears to be a small target as the jammer increases the delay of the retransmitted pulse. This small target may be the aircraft. If you suspect that this technique is being used, your best ECCM action is to tune the TRR to another frequency and observe the dual trace on the target range indicator for a range difference. You should be in the aided rate mode of operation. This mode of operation will at least prevent the radar from automatically tracking the more powerful deception pulse. During any tracking operation, observe the B scope to determine range difference.

d. Blinking. Refer to paragraph 24d.

26.2 (CMHA). Confusion Techniques

In this paragraph we will discuss techniques the enemy may use to confuse you by cluttering your indicators and making you uncertain as to which is the real target among many false targets. What you can do to operate against these techniques is also discussed.

a. Chaff and Corner Reflectors. The enemy may attempt to confuse you by launching nu-

merous bundles of chaff in all directions or by dropping corner reflectors so that there are many target returns in the vicinity of the aircraft. In time you should be able to identify the aircraft return primarily by its speed, but the time lost in the process may be valuable. You can assume that chaff will be used more commonly than corner reflectors since it falls more slowly and thus remains within the radar beam for a longer period of time. Chaff may also be released from the aircraft after you have begun tracking. As the chaff disperses, the returns from it lose their similarity to the aircraft return, slow down, and become large and indistinct. Selecting the short pulse mode will aid you in distinguishing between the chaff and the target. See figure 12.4. In the case of chaff released to the rear of the aircraft, you should track the leading edge of the chaff clutter. By this means, you will be tracking the aircraft, although the aircraft may not be distinguishable from the chaff return. In the case of forward-launched or side-launched chaff, you may more readily become confused and begin tracking a chaff return. See figure 27. The aircraft may be intermittently concealed as it flies close to the chaff. If you note that a radical change in your aided rate is required to maintain track, you should realize that you have probably lost the aircraft target and have begun tracking a chaff return. It would be best not to change the aided rate at all while the aircraft is temporarily concealed by chaff. Wait until the aircraft is again in the clear before making any necessary rate adjustments. You may be able to use the B scope as an aid to tracking the aircraft through the chaff clutter. Depending upon the design of the chaff, it may have less or no effect on the acquisition radar and the B scope may be clear of chaff returns.

b. Spoofers. The initial effect of spoofer targets will be approximately the same as that of spot chaff and corner reflectors. The spoofer targets may leave you in doubt as to which is the real target. Although they offer an advantage to the enemy over reflecting devices because they maintain a realistic aircraft size and motion, they are more susceptible to ECCM action. The factors discussed in paragraph 21c generally apply to the recognition of spoofer

targets on your tracking indicators. The best action is to tune your TRR to another frequency. An additional means of identifying an aircraft among many spoofer returns is by observation of your B scope in the event that the enemy is not generating spoofer targets against the acquisition radar at the same time. In this case, use the B scope to maintain range tracking.

c. Pulse Amplitude Modulated CW. Pulse modulated cw jamming signals produce what is commonly called railing on the tracking indicators. Railing consists of sharp spikes, similar in appearance to the radar transmitted pulse, appearing over the length of the range sweep. If the pulses are synchronized with the radar pulse repetition frequency, the railing will remain stationary on the range sweep. Nonsynchronized railing will move in or out in range. The density of the railing or number of spikes present depends on the pulse repetition frequency of the jamming pulses. You must remain in the aided rate mode to prevent locking on to one of the jamming pulses. The retuning procedure should be effective in reducing the clutter on your indicators.

d. Swept Frequency. Swept frequency jamming is a confusion technique which consists of sweeping the jamming signal through a wide band of frequencies at a slow rate. The effect on the tracking indicator is the appearance of intermittent bursts of jamming signals. Figure 28 contains views of random, intermittent jamming signals as viewed on a tracking indicator. The duration of the burst and the spacing between them will be random. Because of this randomness the target is visible often enough to allow you to maintain a smooth track in the aided mode of operation.

26.3 (CMHA). Obscuration Techniques

In this paragraph we will discuss techniques the enemy may use to obscure target returns on your indicators and prevent you from tracking an important target and what you can do to operate against these techniques. These obscuration techniques include the concealment of targets above or behind a cloud of chaff and the overpowering of target returns with transmission jamming.

a. Chaff Corridor. Against a chaff corridor you may have to rely, to a great extent, on the B scope as an aid in tracking a target, assuming that the chaff has less effect on the acquisition radar. You should be able to track the chaff-launching aircraft on the tracking indicators by tracking the leading edge of the chaff drop. However, the chaff-launching aircraft is probably not the important target. The important targets may be effectively concealed by the clutter on the tracking indicators. Depending on the effectiveness of the chaff on the B scope, you can use this indicator in one of two ways. If the chaff does not obscure the targets on the B scope, you can maintain a track on this scope by using aided rate tracking. If the chaff is multiband, thereby obscuring the targets on the B scope as well as the tracking indicators, you can search the edges of the chaff clutter as seen on the B scope in the event that a target strays out of the concealment of the chaff. You can also switch the TRR to short pulse. This may be helpful in distinguishing between the target and the chaff on the tracking indicators. See figure 12.4.

b. Unmodulated CW. Unmodulated cw jamming tends to drive the receiver toward cutoff. An indication of this condition is a reduction in amplitude of the target and receiver noise on the tracking indicators. If powerful enough, this type of jamming will reduce the amplitude of target video to a level that would be difficult to see on the indicators. Figure 29, views A through F, shows six different intensities of unmodulated cw jamming, the most intense (view F) reducing the target to imperceptible amplitude. Your best ECCM action against this technique is to tune the TRR to an unaffected frequency as observed on the panoramic indicator. If the enemy is not able to track your frequency changes, you should have little trouble evading the jamming frequency. If you are unsuccessful in obtaining a usable signal on the tracking indicators, use the B scope to track the target in range.

c. Modulated CW. The various forms of modulated cw jamming have similar effects on the tracking indicators. The exact effect of a given type of modulated cw jamming is unpredictable. The effect will be an obscuring

clutter on the indicators which may or may not show the waveform of the modulating signal. Figure 30 shows a series of five typical sine wave modulated cw jamming signals (at five different modulation frequencies) as they appear on the tracking indicator. Figure 31 shows a series of five typical square wave modulated cw signals on the same indicator. Figure 32 shows random pulse modulated cw jamming at various pulse repetition frequencies. The effects of noise modulated CW are shown in views A, B and D, figure 33. Initially, your ECCM action against all these techniques should be the retuning procedure selecting either the TTR or TRR video for display. Again, if all attempts to utilize the tracking indicators fail, you should attempt to obtain range information from the B scope as the target tracking radar angle tracks the jamming signal.

d. Direct Noise. Direct noise may be indistinguishable from noise modulated cw. Thus, you should employ the retuning procedure. The results obtained by this procedure should then indicate that the jamming is direct noise and

that you should tune for "holes" in the jamming spectrum. However, the characteristics of direct noise make it very difficult to combat, if it is affecting both the TTR and TRR. Therefore, you may have to depend on the B scope for range information as the target tracking radar angle tracks the jamming.

e. Swept Frequency. Swept frequency jamming is an obscuration technique which sweeps a jamming signal through a wide band of frequencies at a fast rate. The effect on the tracking indicator consists of bursts of jamming signals appearing along the range sweep. See figure 34. These bursts are usually close together, thus increasing the difficulty in tracking the target. By tuning your TTR through the X-band, you may discover that the jamming signal is not being swept across the entire frequency band. There may be a portion of your frequency band within which you can operate without interference. You can also observe your panoramic indicator for clear spots in the Ku-band; then tune the TRR to that frequency and select this transmitter for operation.

CHAPTER 4 (U)

OPERATION IN PRESENCE OF UNINTENTIONAL INTERFERENCE SIGNALS

27 (U). Sources of Unintentional Interference

The three primary sources of unintentional electronic interference are friendly jammers, other radars, and commercial television. By friendly jammers, we mean our own jammers which are operating against the enemy's radars. Transmissions from other radars in the area may be received by your radars. Some television channels operate near the intermediate frequency of the target and missile tracking radars. The transmission from these channels may be picked up by cabling and slip rings and injected into the receiver at the intermediate frequency stages. The subject channels are two, three and four.

28 (U). Detection and Identification

a. Friendly Jamming Signals. Friendly jamming signals may affect either the acquisition radar(s) or tracking radars or all radars of the NIKE system at the same time. (It is conceivable that friendly jammers may affect the missile tracking radar even more than does enemy jamming.) However, it can be assumed that our jammers would be oriented to prevent this possibility. This type interference may take the form of one or more of the enemy ECM techniques discussed in chapter 3. You should not be concerned with whether the jamming is being generated by the enemy or by friendly jammers. Essentially the same problems exist when operating in the presence of jamming regardless of the source. There is one primary characteristic of friendly jamming which may differentiate it from enemy airborne jamming; that is, the jamming source will be stationary.

b. Other Radar Transmissions. Transmissions from other radars, operating in the same frequency bands as the NIKE Systems, may affect the acquisition radar(s) or tracking radars, respectively. This type interference will

affect each of the radars in the same manner as does pulse modulated cw jamming. The effect will most often be similar to the nonsynchronized pulse modulation. However, the pulse repetition frequencies of the two radars may be in synchronization, resulting in a presentation similar to that caused by synchronized pulse modulated cw jamming. If the other radar utilizes a jittered pulse repetition frequency, the effect will be similar to random pulse modulated cw jamming.

c. Commercial Television Transmissions. The effect of television interference is the introduction of tracking errors into the angle error channels. The acquisition radar is not susceptible to this type interference. Detecting the presence of television interference presents no problems to you as the operator. Studies have been made to determine which batteries in the United States are affected by television interference and to what extent these batteries are affected.

29 (U). Operation in Presence of Friendly Interference

In general, friendly interference signals will not hamper your operation to any great extent. Information concerning possible sources of interference during an enemy encounter should be available beforehand so that, if the interference is unavoidable, the effects will at least be predictable.

a. Friendly Jamming Signals. Any friendly jamming signal will probably correspond to one of the enemy ECM techniques discussed in chapter 3. Thus, you should employ the ECCM action for that technique.

b. Other Radar Transmissions. Perhaps the most efficient method of avoiding interference from other radars is changing frequency. Although, in the case of the NAR or LOPAR acquisition radar, the interference suppressor

or MTI may very effectively offset the effects of nonsynchronized and synchronized interference respectively, there is no real need to use these tactics. The other radar will not intentionally follow your frequency change and therefore, by changing frequency you can permanently avoid the interference without sacrificing radar performance. It should be remembered that the use of the interference suppressor or MTI circuits does sacrifice normal radar performance to some extent. The HIPAR radar contains an interference blanker circuit which may be used to eliminate prf interference from an adjacent HIPAR system emplaced within 6,000 feet. The

adjacent radar prf is cabled to your HIPAR system and is used to blank the video presentation during transmission intervals of the adjacent HIPAR system.

c. *Commercial Television Transmissions.* As the radar operator, you can do nothing to offset the effects of television interference. However, it can be assumed that television transmissions will cease in the event of an enemy encounter. Therefore, if system alignment is performed when television transmitters are off the air, the radar will operate normally at least when it is most important, even though the interference may be an annoying problem during drills.

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